Autism and Child Psychopathology Series
Series Editor: Johnny L. Matson

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Clinical Handbook of ADHD Assessment and Treatment Across the Lifespan

Springer

Autism and Child Psychopathology Series

Series Editor

Johnny L. Matson, Professor and Distinguished Research Master (retired), 17211 North Lakeway Avenue, Baton Rouge, LA, USA

Brief Overview

The purpose of this series is to advance knowledge in the broad multidisciplinary fields of autism and various forms of psychopathology (e.g., anxiety and depression). Volumes synthesize research on a range of rapidly expanding topics on assessment, treatment, and etiology.

Description

The **Autism and Child Psychopathology Series** explores a wide range of research and professional methods, procedures, and theories used to enhance positive development and outcomes across the lifespan. Developments in education, medicine, psychology, and applied behavior analysis as well as child and adolescent development across home, school, hospital, and community settings are the focus of this series. Series volumes are both authored and edited, and they provide critical reviews of evidence-based methods. As such, these books serve as a critical reference source for researchers and professionals who deal with developmental disorders and disabilities, most notably autism, intellectual disabilities, challenging behaviors, anxiety, depression, ADHD, developmental coordination disorder, communication disorders, and other common childhood problems. The series addresses important mental health and development difficulties that children and youth, their caregivers, and the professionals who treat them must face. Each volume in the series provides an analysis of methods and procedures that may assist in effectively treating these developmental problems.

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About the Editor

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1 ADHD in Culturally and Linguistically Diverse Children

Ortal Slobodin

The relation between attention deficit hyperactive disorder (ADHD) and culture is not well established. While similar characteristics and prevalence rates have been documented across cultures and countries (Faraone et al., 2003; Fayyad et al., 2017), the literature still indicates that culturally and linguistically minority children are less likely to be diagnosed and treated for ADHD than their nonminority peers (Gómez-Benito et al., 2019; Slobodin & Masalha, 2020; van der Ban et al., 2015). Most scholars today agree that ADHD could be simplified neither as a sociocultural construct nor as an exclusively neurobiological disorder (Roessner et al., 2007). However, there is still an ongoing debate about the impact of sociocultural factors on the manifestation, identification, diagnosis, and treatment of ADHD (Eccleston et al., 2019; Hansson et al., 2015; Singh 2002, 2008).

This chapter is guided by ecological perspectives of development (Bronfenbrenner, 1979, 1995) that view a child's functioning as embedded in family, community, cultural, and historic-political circles. To draw a coherent, up-to-date picture of the role of social and cultural forces on ADHD diagnosis and treatment, the chapter is organized into the four levels of development, as described by the eco-cultural model (Bronfenbrenner, 1979, 1995): (1) child-level factors, (2) the microsystem, (3) the exosystem, and (4) the macrosystem.

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1.1 Establishing an Ecological Perspective on ADHD

Bronfenbrenner's (1977) ecological model of human development conceptualizes a child's functioning as a complex interaction between children's own characteristics and the factors in their environment. According to this view, the child is an active and evolving system that develops using their individual ontogeny as well as through reciprocal interactions with people and things in their environments. Within the ecological model, a child's own characteristics and the various environmental influences are organized into various levels. The first level of the system is related to child-level factors (e.g., age, gender, temperament, cognitive skills). The microsystem is associated with the child's immediate social and physical environment, such as home and school. The last two levels, the exosystem and the macrosystem, consist of more distal factors that can influence the child's functioning, such as neighborhood and cultural influences. The exosystem encompasses concrete manifestations of the macrolevel and includes socioeconomic status (SES), the media, government agencies, resource distribution, parent's workplace, and transport facilities (Bronfenbrenner, 1977). The

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macrosystem is the ideology, culture, and subculture that shape the concrete world of the individual. This level includes the economic, social, educational, legal, and political systems. Due to the macrosystem, contexts are likely to be more homogenous within one society than between societies (Bronfenbrenner, 1979).

The theoretical assumptions of the ecological model are valuable in understanding ADHD among culturally and linguistically diverse children because they highlight the role of culture and context not only in the diagnosis and treatment of ADHD but also in how ADHD is developed and interpreted by significant others (Stolzer, 2005). Understanding ADHD from an ecological perspective also has important implications for developing culturally and ecologically informed interventions that take the interplay between ADHD characteristics and the environments into account (Helle-Valle et al., 2015).

1.2 Sociocultural Risk Factors at the Child Level

Studies applying the ecological perspective to the research of child's neurodevelopmental disorders usually consider personality, genetic, and biological variables, but not cultural ones, as child-level risk factors (Abrams et al., 2005; Walker et al., 2019). Indeed, ADHD was associated with a spectrum of attentional, emotional, cognitive, and motor deficits, including problems in cognitive flexibility, sustained attention, response inhibition, working memory, motivation, and delay aversion (Salomone et al., 2020; Tucha et al., 2017). However, understanding cultural variation in ADHD entails a deeper insight into the influence of context not only on how cognitive skills, such as attention, are culturally defined and perceived but also on how they develop.

In the opening issue of the *Journal of Cultural Cognitive Science*, Posner and Rothbart (2017) advocated for systematic research on how cultural differences (represented by caregivers) influence the brain networks involved in cognition. They provide increasing evidence of how parents as the carriers of culture are involved in the training of brain networks to ensure that the emerging language, number, and attention skills are tuned to the surrounding culture.

In line with this view, a growing body of literature suggested that differences in child-rearing styles across cultures may influence the development of attentional networks (Gutchess et al., 2006; Boduroglu et al., 2009). For example, caregivers' emphasis on labeling objects in Western cultures compared to the emphasis on social interactions in Eastern cultures has been proposed to play a role in the cultural variation of perception (Nisbett & Miyamoto, 2005). Other studies in children (Imada et al., 2013) and adults (Petrova et al., 2013) showed that Asian individuals were more influenced by distractors when moving their eyes to a target, probably due to early socialization of systems responsible for visual orienting during infancy.

A recent meta-analysis of 27 studies (Arora et al., 2020) explored cross-cultural differences in the three networks of attention: alerting (the achievement and maintenance of an alert and vigilant state), orienting (ability to selectively attend to a sensory pathway), and executive functioning (a term that encompasses many functions, such as problem-solving, decision-making, self-regulation, and conflict resolution). The meta-analysis did not reveal any cultural differences in the alerting or orienting network, suggesting that these networks are more biologically determined. There were, however, regional/cultural differences in the executive networks. For instance, Chinese individuals showed smaller executive scores (reflecting more efficient filtering) than those from the USA and Europe. Such differences in executive functions were attributed to differences in child-rearing styles across cultures that may foster analytical versus holistic thinking styles. Posner and Rothbart (2017) suggested that soothing Western infants often involves turning their attention outward toward novel environmental objects (Harman et al., 1997). Therefore, Western participants might attend faster and more frequently to focal objects. Another example of how sociocultural factors shape brain development is the influence of immigration and bilingualism. It has been suggested that switching between languages could serve as executive functions and resolve conflicts in multiple tasks (Carlson & Mettzoff, 2008).

Gene-by-environment interactions may also reflect sociocultural influences on brain development. Studies have found higher heritability of attention dysregulation and ADHD in disadvantaged households (Pike et al., 2006; Wang et al., 2012). In a twin study, Pennington et al. (2009) found that the heritability of ADHD symptoms was higher in low-SES households, suggesting gene-by-environment interaction. Likewise, a longitudinal study following children from 7 months to 2 years (Sheese et al., 2007) observed interactions between parenting quality and variation of the DRD4 gene. Specifically, children with the 7-repeat allele (overrepresented in ADHD) and lower-quality parenting were high in impulsivity while those with higher-quality parenting were normal in impulsivity. Similar results were obtained for activity level and high-intensity stimulation seeking. In ADHD, gene-by-environment interactions have been relatively under-investigated (Gould et al., 2018). However, these findings suggest that the direction of gene-by-environment interaction effects in ADHD may differ amongst environmental variables.

1.3 Sociocultural Risk Factors at the Microsystem

The microsystem is defined as "a pattern of activities, roles, and interpersonal relations experienced by the developing person in a given face-to-face setting with particular physical and material features" (Bronfenbrenner, 1989, p. 67). The microsystem is characterized by direct, intimate, interactional processes with significant others, mainly family members. Bronfenbrenner (1999) suggested that key socialization figures, such as parents and teachers, influence individual development by altering and/or maintaining environments that either encourage or hinder optimal developmental processes.

Parents and teachers are considered the most reliable informants of a child's ADHD symptoms and are usually the primary source of referral (Wolraich et al., 2004). Parents' and teachers' evaluation of a child's functioning is not free from bias. Informants' perceptions of a child's behavior are based on their own cultural upbringing, their attitudes about behavioral problems, and their beliefs about the pros and cons of pharmacotherapy (Ghosh et al., 2017). To refer a child for ADHD care, a teacher or a parent first needs to recognize that a child deviates from the culturally expected standards of behavior (Eiraldi et al., 2006). However, the diagnostic boundary between what is considered gender- and age-appropriate behavior and what is not greatly differs between cultures.

There are several mechanisms through which sociocultural factors, such as norms, expectations, beliefs, and values, may affect the microsystem. First, cultures greatly differ in their tolerance to ADHD core symptoms. What is seen as an acceptable and even desired behavior in a particular culture may be considered unacceptable or abnormal in another. For example, Iranian parents were reported to not consider the behaviors associated with ADHD symptoms as pathologic, but instead to regard these behaviors as "mischievous acts" or a "natural behavioral stage of childhood development" (Sahflei et al., 2011). In a similar vein, the high tolerance for excessive activity in Israeli classrooms makes it difficult to distinguish high activity from pathologic manifestations of ADHD (Hinshaw et al., 2011). A literature review by Miller et al. (2009) suggests that African American parents have a different perception of ADHD than Caucasian American parents, which involves lower thresholds for problem recognition and treatment-seeking. Therefore, African American youth may take longer to have ADHD-related problems addressed, resulting in higher symptom severity.

Additionally, parents' and teachers' knowledge and beliefs about ADHD are influenced by cultural context, including differences in educational systems and teacher training. In a series of cross-cultural studies, Bussing et al. (1998, 2003a, b, 2012) found significant differences in ADHD knowledge and perceptions between minority and nonminority parents, with minority parents (Hispanic and African American) reporting less familiarity and a greater reluctance around the diagnosis and treatment of ADHD. For example, African American parents were found to be less informed about ADHD than Caucasian parents and more likely to attribute ADHD to other causes such as excessive dietary sugar. These racial/ethnic differences were observed even after controlling for several sociodemographic factors. A longitudinal study (Berger-Jenkins et al., 2012) of minority parents of children aged 5–18 years with untreated ADHD that showed medication concerns (parents' concerns about the effectiveness, safety, and possible adverse effects of ADHD medication) were associated with less treatment utilization. Studies of ADHD among Latino families (Lawton et al., 2014, 2016) showed that cultural values of familism and traditional gender roles were associated with sociological/spiritual beliefs. Parents with US mainstream orientation felt that they had more control and were less likely to believe in fate/chance. In contrast, several Latino cultural values were associated with increased beliefs in fate/chance and decreased feelings of parental efficacy and control.

Another important factor that influences parents' and teachers' motivation to identify ADHD symptoms as abnormal behavior and refer children to medical care is a fear of negative stigma (Ghanizadeh & Jafari, 2010; Perry et al., 2005). Stigma is considered a risk factor for ADHD, affecting treatment adherence, treatment efficacy, symptom aggravation, life satisfaction, and well-being (Mueller et al., 2012). Black parents have been found to express more concerns about the stigma associated with mental health problems (Corrigan & Watson, 2007). Some parents believed that a diagnosis of ADHD is associated with a lifetime label, while others considered medicalization as a form of social control with historical roots (Olaniyan et al., 2007). In a similar vein, a cross-cultural comparison between US and South Korean teachers' intentions to refer a child for ADHD care showed that while American teachers' intention was predicted by multiple domains (i.e., attitudes about the referral, beliefs about whether important others would approve of making a referral, and perceived behavioral control in making a referral), among South Korean teachers, behavioral control and perceived stigma were the only predictors. Likewise, a phenomenological study with a group of Arab mothers suggested that the fear of social stigma acted as a barrier to seeking mental health help for their children with ADHD (AlAzzam & Daack-Hirsch, 2015).

Even within cultural contexts, teachers' intention to identify ADHD symptoms and refer a child to medical care may vary with both child's and teacher's race, ethnicity, and culture. Evidence suggests that teachers tend to rate African American children higher on ADHD and conduct-related symptoms and reported significantly higher student–teacher conflict for Black compared to White students (Epstein et al., 1998; Jerome et al., 2009). Research has also shown that teachers hold different perceptions of a child's behavior based on child's background (Gilliam et al., 2016). For example, teachers were more likely to report worse self-regulation for Black children compared to their peers, even when adjusting for factors such as adversity exposure and student–teacher relationships (Loomis, 2021).

While these studies indicate that race, ethnicity, and culture play a critical role in teachers' and parents' perceptions of ADHD-related symptoms, it is still unclear whether differences in adults' ratings of culturally and linguistically diverse children are related to actual differences in child's behavior or rather to differences in informants' perception. Kang and Harvey (2020) tried to address this question by asking parents and teachers to rate video clips of children in classrooms (thus, holding child's behavior constant). Their results showed that White teachers rated Black children's ADHD behaviors higher than did Black parents. Moreover, teachers with more negative attitudes toward African Americans rated Black children's ADHD behaviors and ADHD likelihood higher than teachers who reported less negative racial attitudes. These findings support the view that differences in adults' ratings of Black children may be at least partly attributed to racial differences in perception rather than differences in the child's behavior. Additional support for this view is evident in a recent study by Zulauf-McCurdy and Loomis (2022) who found that child's race moderated the relationship between teacher-reported child self-regulation and teacher-reported parent–teacher relationship. When teachers perceived a strong relationship with a parent of a Black child, they were also more likely to perceive lower problems with child self-regulation. In contrast, when teachers perceived a negative or lower teacher–parent relationship, they perceived increased problems in self-regulation. This pattern was not observed in Latino children.

Overall, these findings suggest that the microsystem level, which includes a child's immediate environment, is greatly affected by sociocultural factors, such as race, ethnicity, and culture. These factors play a crucial role in a child's likelihood to be identified as having ADHD and being referred to as the medical care. Interestingly, while the observed cultural, language, and racial biases in ADHD perception often led to underdiagnosis and undertreatment in culturally and linguistically diverse children, the same biases may also result in an overdiagnosis of neurodevelopmental disorders in these children and to their disproportional representation in special education (Office of Special Education and Rehabilitative Services, 2018). Kang and Harvey (2020) attributed this disparity to the fact that parents (who are also from minority backgrounds) play a greater role in whether or not a child is diagnosed with ADHD, whereas special education placement is under the responsibility of school professionals who are predominantly White.

1.4 Exosystem-Level Risk Factors

Exosystems are the contexts we experience vicariously and yet they have a direct impact on us. These contexts can be empowering (as high-quality childcare) or degrading (as excessive stress at work). In the exosystem level of the ecological model, we can find multiple social factors that may underline sociocultural differences in ADHD diagnosis and treatment. Maybe the most important factor in the exosystem is the family's SES. Living in poor conditions is associated with an increased risk for ADHD (Doshi et al., 2012; Loe & Feldman, 2007). Meta-analyses of dimensions of SES and their association with ADHD indicate that children in families of low SES are on average 1.85–2.21 more likely to have ADHD than their peers in high SES families (Russell et al., 2016). It has been proposed that low SES exposes children and their parents to psychological and environmental stress, which increase the risk of ADHD either directly or through gene–environment interactions (van der Meer et al., 2017). Such stressful conditions include poverty, family dysfunction, trauma, childhood maltreatment, parental mental and physical health problems, and increased exposure to screen media (Swing et al., 2010; Russell et al., 2016; Tiraboschi et al., 2022). The repeated stress typical of poor living conditions causes prolonged exposure to stress hormones such as cortisol, which in turn have detrimental consequences on brain development (Ficks & Waldman, 2009; van der Meer et al., 2017).

In addition, low SES hinders the utilization of ADHD care. For example, the costs for psychotropic medication for African American children, coming into contact with US Child Welfare Agencies, were almost 400 dollars lower than for a White child (Raghavan et al., 2012). SES affects health-care consumption, costs, use, or dosage of psychotropics or medication for

ADHD through multiple factors including geographic disparities in access to specialized health care, language, and communication barriers, lack of culturally appropriate services, lack of medical insurance, and distrust in authorities (Simoni & Drentea, 2016; Zhou et al., 2020). Such factors may explain why although ADHD children may be more suspected of having disabilities, they are still largely underdiagnosed and undertreated (Coker et al., 2016). Because culturally and linguistically diverse families are overrepresented among individuals with low SES, many studies of child psychiatry confounded SES with racial/ethnic minority status (Bussing et al., 2015; Razani et al., 2015). Nevertheless, studies that examined racial and ethnic differences in the diagnosis and treatment of ADHD suggested that racial/ethnic differences still existed although all of the children were qualified for the same medical insurance (Davis et al., 2021; Van den Ban et al., 2015). Thus, other underlying reasons for these differences should be explored.

1.5 Macrolevel Risk Factors

The ecological perspective provides an appropriate conceptual framework to understand the complexity of ADHD because it theorizes links between daily activity, socialization goals, and cognitive dimensions, including emotions, motives, cultural models, values, and scripts. Macrolevel influences on ADHD manifestation, diagnosis, and treatment encompass cultural, political, economic, and geographic conditions. Thus, ADHD in culturally and linguistically diverse children may be understood as representing a complex interaction between a child's behavior and cultural expectations, including religious rules, emotional expression, and parental socialization goals. Several ADHD studies employed the distinction between individualistic and collectivistic orientations to approach cultural variations in emotional regulation and socialization goals (Perdomo et al., 2020; Tan & Teng, 2020). In individualistic cultures, socialization is oriented toward developing a sense of autonomy, separateness, and agency in the child, as well as toward the development of the child's talents and skills to enhance self-fulfillment (Phalet & Schönpflug, 2001). Individualistic cultures attempt to distribute power and status more evenly. Therefore, they encourage open and direct emotional expression when interacting with people of higher status (Gottman et al., 1997; Matsumoto, 2007). In collectivistic cultures, however, socialization practices are often oriented toward goals such as group agreement and cooperation (Greenfield et al., 2003; Keller et al., 2006), which can shape children's behavioral and emotional responses (e.g., obedience) (DiBartolo & Rendon, 2012; Yang & Wang, 2019). These cultures value emotions less and require individual-level control and suppression for the maintenance of in-group cohesion and harmony (Mastumoto et al., 2008).

Cultural values affect not only parental emotional socialization but also how such parental practices are perceived and interpreted by children. Previous studies found that although parents from collectivistic cultural groups (e.g., immigrant Asian Indian; Latinx, Chinese; Bedouin Arabs) often used more non-supportive responses to their child's negative emotions than individualistic parents, these emotion socialization practices had fewer negative emotional and motivational effects among children of collectivist background (Assor et al., 2020; Lugo-Candelas et al., 2015; McCord & Raval, 2016). For example, a comparison between Belgian and Chinese adolescents' perceptions and reactions to a vignette depicting parental guilt-induction showed that Chinese adolescents perceived such parental behavior as less controlling than their Belgian peers (Chen et al., 2016). These findings are supported by a line of research showing cultural differences in physiological reactivity in service of emotion suppression (Rapp et al., 2022; Soto et al., 2016). Translating these findings into the ADHD context suggests that the ways neurobiological deficits related to ADHD would be manifested, perceived, and regulated by children, parents, and teachers may greatly differ between various sociocultural settings.

Cultural and historical trends also shape educational norms and expectations, which, in turn, may affect ADHD presentation. In China, for example, education in schools during the Cultural Revolution was undervalued, at the expense of physical work. However, sociopolitical changes, such as one-child policies and economic development contributed to the prioritization of education. As a result, children have been under strong pressure to achieve at high levels. Strong cultural expectations for achievement, high criticism, hierarchy, and authority as well as the predominant practice of passive student learning in lecture-style classrooms may exacerbate attention and behavior problems (Hinshaw et al., 2011; Hsu et al., 2022).

Cultural expectations for conformity greatly limit the provision of individualized education plans in China. Other countries, however, such as Japan, require educators to provide individualized support for children with developmental disabilities. Educational policies and laws require schools to assign an educator to serve as a special education coordinator to work collaboratively with parents and other educators to plan and implement support for children who are struggling in general education classrooms (Kayama & Haight, 2012). A study comparing ADHD services in South Korea and the USA revealed that American students are eligible for special education services and that every parent or teacher can refer a student for special education services. Once identified as having ADHD, students can receive special education services and other available services, including an individualized education program. In contrast, students with ADHD in South Korea are not recognized as having a disability under the Special Education Promotion Law, which likely influences a teacher's identification and referral of students who have ADHD (Lee, 2014).

Another factor affecting ADHD diagnosis and treatment at the macrosystem level is perceived discrimination. Explicit and implicit racial/ethnic biases have been shown to have adverse effects on clinicians, educators, and parents' views and contribute to inequities in treatment and care (Hall et al., 2016 for a systematic review). In medical systems, professionals may be biased toward interpreting child's behavior based on ethnicity, reducing opportunities to be referred to ADHD care. For example, mental health providers tended to associate the behavior of African American adolescents with criminal orientations, whereas negative behavior among White adolescents was attributed to mental health problems. Consequently, minority adolescents, particularly those from an African American background, were more likely to be referred for restrictive measures and service placements, rather than community-based interventions (Slade, 2004). In school systems, racial biases have been demonstrated in teachers' perceptions and expectations of children's behavior and academic success (Perdomo et al., 2020). In a study of over 8000 tenth grade American public-school students, White and non-Black teachers were significantly more likely than Black children to expect that Black students would not graduate high school and less likely to expect that they would attain a college degree (Gershenson et al., 2015). In contrast, Kang and Harvey (2020) showed that Black parents' and teachers' experiences of racial discrimination were associated with higher ratings of children's ADHD behaviors, regardless of child's race and gender. It was suggested that racial discrimination may lead adults to perceive the world through a more negative lens. Therefore, Black parents were more likely to perceive and rate a child's behavior as problematic.

The selection and utilization of ADHD treatment are affected by macrolevel factors including health insurance regulations, reimbursement, health policies, values, and norms. The American Academy of Pediatrics (AAP) 2019 clinical guidelines for the diagnosis and treatment of ADHD in children and adolescents suggest that FDA-approved medication for ADHD and parent training in behavior management should be routinely recommended for school-aged children with ADHD (Wolraich et al., 2019). However, profound disparities in treatment modalities have been reported between countries and contexts. Probably, such differences reflect an interaction between differences in responses in individual/family characteristics (health insurance, health status, access to care variables), with cultural values and norms that affect parents' response to child behavioral cues, trust in the health-care system, and their confidence in using medications (Hudson et al., 2007). In China, for example, high levels of stigma related to mental illness, a lack of training in the treatment of ADHD among medical and mental health professionals, and strong controls on potentially addictive medications enforce a stringent policy of psychostimulants use (a maximum of 2 weeks for any methylphenidate prescriptions). Also, because of the cultural acceptance of herbal treatments, they are used as much as, if not more than, stimulant medications (Hinshaw et al., 2011). In Australia, however, socioeconomically disadvantaged individuals had an increased rate of stimulant use, probably due to greater national policy support for universal access to health care (Claver et al., 2007).

Finally, macrosystem influences on ADHD diagnosis and treatment include the role of media.

Media representations of ADHD are often stigmatizing and criticizing. Many representations of ADHD exclusively focus on its sociocultural nature (e.g., poor parenting, low-quality schooling, or current societal values related to increased competition) (Hinshaw, 2018; Hinshaw & Scheffler, 2014). Other media representations criticize the use of stimulant medication, suggesting that drug manufacturers mislead the public and questioning the validity of parental report and public health surveys of ADHD (Schwarz, 2016).

1.6 Methodological and Conceptual Challenges in Studying ADHD Among Culturally and Linguistically Diverse Children

Many scholars worldwide have criticized psychiatric and psychological research for overlooking diverse populations (Liang et al., 2016; Slobodin & de Jong, 2015; Ungar, 2008). In his seminal paper, Arnett (2008, 2016) proposed that psychological research published in APA journals focused too narrowly on Americans, who comprise less than 5% of the world's population. This focus resulted in an incomplete understanding of psychology and a failure to adequately represent humanity. Ten years later, 11% of the world's population is represented in top psychology journals, but 89% of the world's population continues to be neglected (Thalmayer et al., 2021). The narrowness of psychological and psychiatric research was attributed to two main principles: the abundance of research resources in wealthier countries (especially well-funded US universities) and psychology's dominant philosophy of science that aspire to identify human universals using experimental settings (Arnett, 2008). In an analysis of studies published in 2007 in eight prominent journals covering four subdisciplines, Cundiff (2012) showed that the assumption of White men as the norm is still present in psychology.

Other structural and sociocultural reasons for the underrepresentation of minority populations in research include power differences (defined by situations of unequal levels of authority and influence between the researcher and research participants), reluctance to expose private issues, limited access to technology, and physical segregation (Alvarez et al., 2006; Hilton et al., 2010; Serfaty et al., 2020). There are also psychiatric conditions, such as selective mutism, in which DSM-based diagnosis excludes children with limited language proficiency. Thus, despite having increased rates of the disorder, minority children are often excluded from study samples (Topperlberg et al., 2005).

Nevertheless, even when culturally and linguistically diverse children are included in ADHD studies, the validity and reliability of cross-cultural research are still questionable (Roessner et al., 2007; Wild et al., 2005). Studies in the field of ADHD often use an empirically based approach that relies on a quantitative taxonomy in community samples. However, because clinical cut-off scores of rating scales are not necessarily uniform across all cultures and the adaptation of rating scales in cross-cultural research is far from being optimal, both sampling method and outcome data might be confounded by the same problems of cross-cultural validity

(Roessner et al., 2007). A meta-regression analysis by Polanczyk et al. (2007) showed that despite international variation in prevalence estimates for ADHD, most of the cross-country variation was attributable to methodological differences, such as diverging definitions of the disorder, different algorithms for combining assessment information, and using different diagnostic and impairment criteria, rather than to cultural or national-level factors. For example, a recent systematic review of ADHD in Arab countries revealed that only 9 of 58 studies used *DSM* criteria for ADHD (Alkhateeb & Alhadidi, 2019).

These studies suggest that analyzing cross-cultural research of ADHD should balance two opposite views of the disorder: the first view considers ADHD as a defined neurodevelopmental condition (with uniform core symptoms) that is subjected to methodological biases. The other view considers ADHD as a socially constructed phenomenon and argues against imposing the Western construction of normality and abnormality on local populations in the name of science (Singh et al., 2013). In a recent effort to integrate these two contradicting perspectives, Filipe (2022) suggested that the "global" and the "local" need not be analyzed as absolutes or binaries. Rather, understanding the globalization of ADHD and the local adoption of any given medical entity or pharmaceutical practice entails more attention to how these practices are temporarily and spatially localized and socialized.

1.7 Concluding Remarks

The US Census Bureau projects that by 2020, greater than 50% of the nation's youth will be from minority racial and ethnic backgrounds. Misdiagnoses and undertreatment of ADHD in culturally and linguistically diverse children may have adverse long-term influences on their academic, professional, social, and personal development and increase the likelihood of mental health problems and risk behaviors (Arnold et al., 2020; Harpin et al., 2016). Therefore, it is increasingly important to understand how ethnicity, race, migration status, and SES biologically and socially influence ADHD throughout the life course (Cheng & Goodman, 2015; Hinshaw, 2018).

Future research on ADHD should focus on developing culturally relevant measurements and interventions. The American Psychiatric Association (APA) and the DSM-5 Cross-Cultural Issues Subgroup (DCCIS) jointly developed a tool to assist clinicians in making person-centered cultural assessments to inform diagnosis and treatment planning: the Cultural Formulation Interview (CFI) (DeSilva et al., 2015). This tool allows clinicians and researchers to obtain information about the impact of culture on key aspects of an individual's clinical presentation and care. Developing culturally relevant measures and interventions for ADHD should integrate "emic" (local) and "etic" (imported) elements (Fetvadjiev et al., 2015; Zeinoun et al., 2017). While etic studies export materials to a new culture, translating existing surveys, methods, or protocols, they preclude learning much else from the new context. Emic studies, on the other hand, explore the local culture in-depth (Cheung et al., 2011). Jordan et al.'s (2011) model for developing culturally sensitive mental health interventions provide an appealing approach for such integration, weaving together local and global knowledge of mental health. According to the model, developing culturally competent interventions mandates a preliminary qualitative phase to establish a systematic understanding of the community's needs and preferences and determine tentative intervention aims.

To date, much of what we know about cultural differences in ADHD has come out of racial/ethnic group comparisons. However, while ethnicity and race are often considered proxies for cultural values, they are not the same. Research suggests that a diverse range of factors, including parental education level and neighborhood characteristics, could be meaningful indices of mental health rather than racial/ethnic group membership alone (Jablonska et al., 2020; Park et al., 2014). Therefore, further research should reach beyond the traditional distal assessments of culture such as categorical demographics and develop a deeper understanding of cultural values, norms, and expectations (Rapp et al., 2022).

DuPaul (2020) has advocated for increasing the ecological validity of cross-cultural research of ADHD by conducting more investigations in actual school and/or home contexts. Despite challenges regarding control of extraneous classroom or home variables, such in vivo studies may enhance the validity and applicability of this research literature.

Finally, further research is needed to determine the efficacy of culturally adaptive practices, including adaptations in terms of language, content, goals, methods, and context of services in reducing ADHD symptoms. Given that culturally and linguistically diverse families tend to underutilize mental health services, community settings, such as schools, may provide a more optimal and less stigmatized setting (Green et al., 2020).

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2 Gender Differences in Adults with ADHD

Ashely Schiros, Andrew S. London, and Kevin M. Antshel

2.1 ADHD in Adulthood

ADHD is increasingly recognized as a lifespan/life-course disorder. ADHD was originally conceptualized as a childhood disorder that subsided in adolescence. However, now, there is a vast literature detailing the persistence of ADHD symptoms and related impairments into adulthood. Moreover, ADHD is increasingly diagnosed for the first time in adulthood, especially among women (London & Landes, 2021). The most recent prevalence estimates of adult ADHD ranges from 2.58% to 6.78% globally (Song et al., 2021), and the annual prevalence and incidence rates for adult ADHD have significantly increased over the past decade (Chung et al., 2019). There is a notable 5% prevalence of adult ADHD on college campuses, and one-quarter of all college students receiving disability services have an ADHD diagnosis (DuPaul et al., 2009). Clearly, ADHD in adulthood is a prevalent mental health concern that warrants clinical attention.

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2.1.1 Presentation of Adult ADHD

While a diagnosis and symptoms of ADHD may persist from childhood to adulthood, a new diagnosis of ADHD in adulthood requires that five or more *DSM-5* symptoms of hyperactivity/impulsivity and/or inattention (compared to six or more symptoms for diagnosing ADHD in children) are present in two or more settings, contribute to functional impairment, are not attributable to another disorder, and several of these symptoms have been present before age 12. Adults can be diagnosed with any of the three presentations of ADHD (i.e., predominately inattentive, predominately hyperactive/impulsive, or combined). The combined presentation is the most common diagnosis in adult ADHD, and inattentive symptoms are the most frequently endorsed symptoms by adults with ADHD (Wilens et al., 2009). Although hyperactivity/impulsivity symptoms decrease with age, inattentive symptoms are often stable over time and may be particularly salient in adult ADHD (Döpfner et al., 2015). This salience of symptoms is typically reversed in childhood ADHD because parents, teachers, and peers are more apt to notice hyperactive/impulsive symptoms in children with ADHD. The behavioral symptoms of fidgeting, restlessness, talkativeness, and loudness in childhood ADHD are often labeled "disruptive" by parents and teachers, while symptoms of inattention may be overlooked until they are impairing. By contrast, adults with ADHD are more likely to find

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inattentive symptoms, such as distractibility, forgetfulness, and organizational and planning difficulties, to be most impairing and disruptive to the fulfillment of adult roles.

2.1.2 Impairments in Adult ADHD

Symptoms of ADHD in adulthood can manifest in multiple settings and contribute to functional impairments in diverse domains. Whereas ADHD symptoms among youth are observed in school and home settings, adults have many more responsibilities, more people depending on them, and greater demands for self-management, which together create more domains for ADHD-related functional impairment to become evident. Inattentive symptoms exhibited by adults with ADHD contribute to impairments in instrumental activities of daily living (IIADL) (Faraone et al., 2004), such as planning daily chores and activities, paying bills, organizing mail and important documents, and keeping appointments. For some adults with ADHD, the inability to manage bills, plan, and budget, or inhibit impulse buying contributes to chronic financial management difficulty and financial strain (Antshel & Barkley, 2009; Bangma et al., 2020). Comparatively, children with ADHD have the structure and support of their parents for many of these IADL and do not yet need to manage such an extensive array of responsibilities in the home. In addition to impairments in household tasks or IADL, poor academic performance in college (Arnold et al., 2020; Weyandt et al., 2013) and occupational difficulties are common among adults with ADHD. Compared to those without ADHD, adults with ADHD report lower work productivity (Joseph et al., 2019), more work-related impairments (Fuermaier et al., 2021), greater job instability (Gordon & Fabiano, 2019), lower job attainment (Gordon & Fabiano, 2019), and lower income (Gordon & Fabiano, 2019; Joseph et al., 2019).

Beyond IADL and work-related impairments, ADHD in adulthood is associated with higher likelihoods of injuries, physical health conditions, functional limitations, and fair/poor health, respectively (Landes & London, 2021). It is also linked to a widespread pattern of engaging in risky behaviors (Shoham et al., 2019). These risky behaviors include greater engagement in substance use (Faraone et al., 2007; Rooney et al., 2012), condomless and casual sex (Flory et al., 2006; Hosain et al., 2012), and gambling (Theule et al., 2019). Risky and distracted driving is also more common among adults with, compared to adults without, ADHD (Fuermaier et al., 2017; Randell et al., 2020). Adult drivers who have ADHD are more likely to be in a car accident (Merkel et al., 2016) and to drive drunk (Koisaari et al., 2015) than adult drivers without ADHD. Most troublingly, adults with ADHD have higher rates of mortality than adults without ADHD (London & Landes, 2016, 2022), which may in part be explained by the increased engagement in risky behaviors and inattention exhibited by adults with ADHD.

One similar area of impairment between children and adults is in the domain of social impairments. Adults with ADHD exhibit greater social impairments compared to adults without ADHD (Weyandt et al., 2013). Socially, adults with ADHD are more likely to report stress and conflict in their family and interpersonal relationships (Asherson et al., 2012). Romantic relationships are an important feature of adult life – one which is less salient during childhood – and adults with ADHD are more likely to have short-lived and discordant romantic relationships compared to adults without ADHD (Wymbs et al., 2021). Adults with ADHD report poorer marital adjustment (Eakin et al., 2004), and ADHD is associated with negative impacts on marital relationships (Ersoy & Topçu Ersoy, 2019). ADHD in adulthood affects parenthood, such that parents with ADHD exhibit less positive, more harsh, and more lax parenting styles than parents without ADHD (Park et al., 2017).

Another area of similarity between ADHD in adulthood and ADHD in childhood is the high rate of comorbid internalizing conditions. ADHD in adulthood is associated with increased levels of anxiety and depression (Nelson & Liebel, 2018), psychological distress (Landes & London, 2021), emotion dysregulation (Retz et al., 2012), and psychiatric comorbidities (Anker et al., 2018). Interestingly, these social difficulties and internalizing symptoms (e.g., anxiety, depression) may be particularly salient among adult women with ADHD.

2.2 Gender Differences in ADHD

ADHD is one of the most commonly diagnosed neurodevelopmental disorders, yet conjecture exists over the prevalence and phenotypic profile of symptoms in girls and women. Although ADHD was originally believed to be a predominantly male disorder – and specifically, a male, childhood disorder (Cantwell, 1996; London & Landes, 2021) – there is a growing awareness of the prevalence of ADHD in girls and women. Global prevalence estimates for childhood ADHD show a male-to-female ratio of 3:1 in community samples and between 5:1 and 9:1 in clinical samples (Ramtekkar et al., 2010; Willcutt, 2012). However, this gender disparity in prevalence rates lessens in adolescent and adult populations. By adulthood, the gender ratio in ADHD is approximately 2:1 (Danielson et al., 2018; Kessler et al., 2006). The gender gap in the prevalence of ADHD among adults decreased by 31.1% from 2007 to 2012 due to increased prevalence among adult women of all ages (London & Landes, 2021). Given the growing awareness of the prevalence of ADHD among women there are many important gender differences in the diagnosis, presentation, and treatment of ADHD among adult females that merit discussion. However, to provide context, it is important to begin with a review of some of the theories that have been advanced to explain differences in the presentation and rate of diagnosis in ADHD among women.

2.2.1 Theories of Gender Differences in ADHD

In psychology, the "gender paradox" stipulates that any gender that has a lower prevalence rate for any condition will have a more severe phenotype, including higher rates of psychiatric comorbidity (Loeber & Keenan, 1994). The polygenetic multiple threshold model posits that the gender with the lower prevalence will require increased genetic vulnerability and/or environmental risks factors in order to be diagnosed with the condition (Taylor et al., 2016). The constitutional variability theory posits that boys mature slower than girls and thus have a higher risk for a variety of psychopathologies. All of these general theories suggest that girls with ADHD will have a more severe presentation than boys with ADHD.

More specific to ADHD, it is theorized that the existing gender disparities in rates of ADHD diagnoses can at least in part be attributed to the samples used to create the *DSM* criteria. The *DSM* criteria for ADHD were based on field studies that utilized primarily male samples (Lahey et al., 1994). Given that these field studies used samples in which 80% or more of the participants were boys, the criteria derived from these samples were inherently biased toward the manifestation of ADHD among boys. Therefore, the *DSM* criteria for ADHD are likely to be more applicable to boys and men than girls and women and may lead to the misidentification or underrepresentation of ADHD in girls and women. The historical gender bias in diagnosis is changing among adults as a result of the relatively recent greater diagnosis of ADHD among adult women than among adult men of all ages (London & Landes, 2021).

In addition to field trial sample biases, the socialization of gender roles in childhood also contributes to the gender differences in psychopathology (Crick & Zahn-Waxler, 2003; Zahn-Waxler et al., 2008). From a very young age, parents, schools, and society impose socially constructed gender roles on children, including the use of gendered speech (e.g., "you're a good girl"), the promotion of gendered toys (e.g., dolls are for girls, trucks are for boys), and segregation of children by gender. Socialization practices employed by adults attempt to condition disruptive behaviors characteristic of hyperactive/impulsive ADHD (e.g., running around, climbing, verbal intrusion, talkativeness, "handsy-ness") out of young girls, whereas boys typically receive less punishment for these disruptive behaviors. Because these hyperactive/impulsive behaviors are deemed more socially acceptable and are less frequently punished among boys, these hyperactive/impulsive symptoms are more likely to persist and later be identified and contribute to an ADHD diagnosis among males. Conversely, from an early age, the punishment and low tolerance for hyperactive/impulsive behavior among girls likely decreases the presentation of these behaviors. At the same time, among girls, less overtly noticeable inattentive symptoms may persist, leading to the later or lack of identification of ADHD among girls (Ohan et al., 2008).

Gendered stereotypes about ADHD also exist (Quinn & Wigal, 2004) and may be reinforced by the gender bias in ADHD diagnostic criteria and rates of diagnosis. A national study of perceptions of ADHD reported that a majority of the general public (58%) and teachers (82%) believe that ADHD is more prevalent among boys (Quinn & Wigal, 2004). Teachers have greater difficulties identifying girls, compared to boys, with ADHD (Groenewald et al., 2009; Quinn & Wigal, 2004) and are more likely to attribute ADHD symptoms among girls to emotional problems than ADHD (Groenewald et al., 2009). Finally, teachers and parents are less likely to consider treatment for girls with ADHD due to a belief that girls are less likely than males to benefit from psychological or educational interventions (Ohan & Visser, 2009). Although there is evidence that ADHD is associated with significant functional impairments among girls and women, ADHD is likely underdiagnosed and undertreated among girls and women (Kok et al., 2020; Ramtekkar et al., 2010).

Although the gender gap in ADHD diagnosis persists, it declines with age. There are three leading explanations for why the gender gap in ADHD prevalence declines with age. The first is that girls and women with ADHD are more likely to present with predominantly inattentive symptoms (Biederman et al., 2002), which may become more salient later in development due to increasing academic and occupational demands (Döpfner et al., 2015). Children with hyperactive/impulsive symptoms are more likely to incite concerns early on because adults, such as parents and teachers, tend to find these symptoms bothersome. By comparison, girls with inattentive ADHD may go unnoticed until their symptoms interfere with functioning, leading to later diagnosis for girls and the lessening of the gender gap with age. Likewise, emotional problems and internalizing symptoms (Mowlem et al., 2019a, b), which are particularly common among girls and women with ADHD, may contribute to eventual, yet later, identification of ADHD among girls and women. These emotional problems and internalizing symptoms among females with ADHD (Mowlem et al., 2019a, b) often become prominent during the transition from adolescence into adulthood (Durbeej et al., 2019) and may contribute to ADHD and related concerns rising to clinical attention later in life compared to males. Finally, children and adolescents are most often referred for an ADHD evaluation by parents and/or teachers, while adults self-refer more often. Women are more likely than men to use a wide variety of health-care resources, including mental health treatment (Millenet et al., 2018). Thus, in addition to the inherent bias in the ADHD criteria and differing symptom presentation among girls and women, gender role socialization and referral biases may also contribute to gender prevalence rate differences in ADHD.

2.2.2 Gender Differences in ADHD Presentation

While the core defining symptoms of ADHD (i.e., inattention and/or hyperactivity/impulsivity) are identical among men and women with the disorder (American Psychiatric Association, 2013), there are notable gender differences in ADHD symptom phenomenology (Arcia & Conners, 1998; Biederman et al., 2004). Across the lifespan, men more likely to be diagnosed with the hyperactive or combined presentation of ADHD, whereas women are more likely to be diagnosed with the predominantly inattentive presentation of ADHD (Gershon, 2002; O'Brien et al., 2010). Boys and men with ADHD also more commonly present with externalizing symptoms, such as impulsivity, disinhibition, talkativeness, and aggression, compared to girls and women with ADHD (Gaub & Carlson, 1997; Gershon, 2002; O'Brien et al., 2010). Conversely, women with ADHD are more likely than men with ADHD to report internalizing symptoms, present with greater distractibility and poorer working memory and organizational skills (Gershon, 2002; O'Brien et al., 2010), and exhibit stronger cognitive flexibility and motor response inhibition (Loyer Carbonneau et al., 2021). Although men, in general, are more likely to present with hyperactive/impulsive ADHD, it is worth noting that verbal impulsivity (e.g., interrupting conversations) and talkativeness are more common among women with ADHD, while physical impulsivity (e.g., throwing something when upset) and hyperactivity are more common among men with ADHD (Young et al., 2020).

In addition to gender differences in ADHD presentation and symptomology among adults, there are also gender differences in diagnosed comorbidities among adolescents and adults with ADHD. Comorbid substance use and conduct disorders are more common in adolescent and adult men with ADHD compared to adolescent and adult women with ADHD. Conversely, comorbid internalizing disorders (Yoshimasu et al., 2018), borderline personality disorder (Soendergaard et al., 2016), and suicidality (Meza et al., 2020) are more common among adolescent and adult women with ADHD compared to adolescent and adult men with ADHD.

Clearly, there are differences in the rates of ADHD diagnosis, ADHD presentation, and associated comorbidities and symptoms between men and women with ADHD. Given the aforementioned concerns about the gender disparity in rates of diagnosis and the reliance on male samples in the creation of the *DSM* ADHD criteria, recent and ongoing research has focused on examining a range of issues that are unique to women with ADHD.

2.3 Symptoms and Impairments Among Women with ADHD

There are several domains of functioning that appear to be especially impaired among women with ADHD relative to men with ADHD, and several gender-specific issues in adulthood (e.g., motherhood) that can be affected by ADHD. Much of what we know about young adult ADHD among women has emanated from the Berkeley Girls Study of ADHD (BGALS). For an overview of study methodology and findings, see Owens et al. (2017).

2.3.1 Social Difficulties, Romantic Relationships, and Motherhood

Women with ADHD report significantly greater social and interpersonal difficulties than males with ADHD. Specifically, women with ADHD endorse higher rates of social impairment than men with ADHD (Fedele et al., 2012). Consistent with gender role socialization, social and relational deficits may be more salient, and therefore garner greater attention, among women than men with ADHD. Peer rejection and feelings of stigmatization in social relationships are common among women with ADHD (Henry & Hill Jones, 2011; Holthe & Langvik, 2017). In romantic relationships, women with ADHD are more likely than men with ADHD to be in relationships in which their partner is concerned with their ADHD symptoms and is dissatisfied. Women with ADHD have fewer romantic partners than their female counterparts without ADHD (Babinski et al., 2011), which may be evidence of difficulty in initiating and maintaining satisfying romantic relationships. Although adults with ADHD, in general, are more likely than those without ADHD to experience marital conflict, there is evidence to suggest that rates of divorce are higher among women with ADHD than among men with ADHD (Minde et al., 2003). Interestingly, this pattern of greater overall social impairment among women with ADHD is consistent across age, in both children and adults.

However, social impairments in romantic relationships and in parenthood are unique to the concerns of adolescents and adults with ADHD.

Motherhood is a unique female experience that can be both incredibly rewarding and taxing. It is also an experience that can be affected significantly by ADHD. Mothers with ADHD report that they experience significant pressure to comply with various gendered expectations of motherhood, such as housekeeping and planning, organizing, and managing family life (Lassinantti & Almqvist, 2021). These expectations often manifest as tasks (e.g., housekeeping, supervision, scheduling) that are associated with motherhood much more than fatherhood. Fundamentally, the demands of motherhood are wide reaching and require time-management and organizational skills that are often impaired among women with ADHD. Among mothers, inattentive ADHD can exacerbate the difficulty of these organizational demands, leading to greater maternal stress and difficulty implementing parenting skills. For example, mothers with ADHD are less consistent in monitoring and disciplining child behavior and have greater difficulties in problem-solving about childrearing issues compared to mothers without ADHD (Murray & Johnston, 2006). Some women with ADHD have reported that they were unable to simultaneously manage working and being a mother, resulting in the choice to quit their jobs during the early years of motherhood (Holthe & Langvik, 2017). The increased responsibilities of motherhood may increase overall stress, and women with ADHD may be more susceptible to stress and emotional reactivity due to emotion dysregulation problems associated with their ADHD (Holthe & Langvik, 2017).

2.3.2 Emotion Dysregulation

Although not currently part of the diagnostic criteria for ADHD for either children or adults, across the lifespan/life course, emotion dysregulation is a common associated feature that may be especially impactful among women (Christiansen et al., 2019). Emotion dysregulation refers to the inability to modulate an emotional response to a stimulus in subservice of a goal, and may include emotional lability and intense emotional reactivity. Increased negative emotionality, heightened emotional reactivity, and decreased implementation of effective emotion regulation strategies are all exhibited among adults with ADHD (Beheshti et al., 2020; Christiansen et al., 2019). These deficits in emotion regulation may contribute to greater emotional distress, less effective coping in stressful situations, and increased social conflict among adults with ADHD. In fact, the evidence for emotion regulation deficits associated with ADHD is so strong that many have argued that emotion dysregulation is a core feature of ADHD and should be added to the *DSM* diagnostic criteria for the disorder in the future (Barkley, 2022; Hirsch et al., 2018).

Similar patterns of emotion dysregulation and associated impairments are seen among youth with ADHD. Among youth with ADHD, problems related to emotion dysregulation are more salient, and potentially more impairing, among girls than among boys (Mowlem et al., 2019a, b). Less research has focused on gender differences in emotion dysregulation in ADHD during adulthood, but one study found that emotion dysregulation and issues of self-concept may be more pronounced among women with ADHD than their male counterparts (Hirsch et al., 2018).

Emotion dysregulation may be an important transdiagnostic mechanism that explains the overlap between ADHD and several common comorbidities, particularly those that are more prevalent among women. As noted earlier in this chapter, women with ADHD are more likely to present with comorbid borderline personality disorder or comorbid eating disorders than men with ADHD (Soendergaard et al., 2016). Emotion dysregulation is implicated in these comorbidities. For instance, a systematic review identified emotion dysregulation as a mediator explaining the relationship between ADHD and eating disorders (El Archi et al., 2020). Similarly, emotional lability is a core feature of borderline personality disorder, and emotion dysregulation problems are most pronounced in individuals with comorbid ADHD and borderline personality disorder compared to either disorder alone (Ditrich et al., 2021). Taken together, the evidence suggests that emotion dysregulation is a common and impairing symptom in adult ADHD, especially among women, and may be a transdiagnostic factor in the co-occurrence of ADHD with eating disorders or borderline personality disorder.

2.3.3 Self-Esteem and Internalizing Problems

Low self-esteem and internalizing problems are another area of heightened concern among women with ADHD. Compared to men with ADHD, women with ADHD report more problems with their self-concept and self-image (Hirsch et al., 2018). As noted previously, women with ADHD are more likely to present with greater internalizing symptoms and disorders than men with ADHD (Soendergaard et al., 2016; Yoshimasu et al., 2018). Moreover, these increased internalizing symptoms among women with ADHD may have more severe behavioral consequences. Young adult women with ADHD display greater rates of self-harm behavior, including non-suicidal self-injurious behaviors, and an increased risk for suicide (Hinshaw et al., 2021). By adolescence, compared to traditionally developing girls, girls with ADHD are at increased risk for suicide attempts (Beauchaine et al., 2019; Meza et al., 2020) and non-suicidal self-injurious behaviors (Beauchaine et al., 2019; Hinshaw et al., 2021; Meza et al., 2020). Longitudinal research has indicated that internalizing symptoms (Swanson et al., 2014) and impulsivity (Meza et al., 2020) during youth are partial mediators that explain suicide attempts in young adult women with ADHD.

2.3.4 Sexual Behaviors

Multiple studies have reported that women with ADHD are at increased risk for risky sexual behaviors and outcomes compared to both men with ADHD and women without ADHD. For example, the BGALS reported a fourfold greater risk for unplanned pregnancy and earlier engagement in oral sex among women with ADHD followed longitudinally into adulthood (Halkett & Hinshaw, 2021). Others have reported a significantly increased risk for teenage motherhood in girls with ADHD compared to those without ADHD (Skoglund et al., 2019). Some evidence suggests that teenage academic underachievement mediates the relationship between childhood ADHD symptoms and risky sexual behaviors (condomless sex) resulting in unplanned pregnancies (Owens & Hinshaw, 2020).

During college, women with ADHD are less likely to use a condom during sex compared to men with ADHD and women without ADHD (Huggins et al., 2015), and college students with ADHD report a greater number of sexual partners, lower rates of condom use, and higher rates of STIs and unplanned pregnancies compared to college students without ADHD (Rohacek et al., in press). Risky sexual behavior in college students with ADHD is moderated by substance use (e.g., alcohol use, binge drinking, cannabis use), indicating that college students with ADHD who use alcohol and/or cannabis may be at particularly high risk for deleterious sexual health outcomes (Rohacek et al., in press). This heightened engagement in risky sexual behaviors among women with ADHD may be explained using the framework of expected utility in decision theory, such that risky decisions (e.g., condomless sex) are attributable to overweighing potential benefits (e.g., sexual arousal) and underweighting potential losses (e.g., STI acquisition) (Nigg et al., 2017; Shoham et al., 2020).

Overall, gender differences in adult ADHD can be found in the core symptoms of ADHD, rates of comorbidities, and features associated with the disorder. ADHD in adulthood is similar to childhood ADHD, yet distinctions can be found in the wider reaching domains of impairment seen in adult, compared to child, ADHD. Inattentive symptoms are typically more impairing than impulsive/hyperactive symptoms among adults with ADHD, and women with ADHD may find these inattentive symptoms impairing in their social relationships and during motherhood. With these noted areas of difficulty in adult ADHD, considerations must be made with regard to the assessment, diagnosis, and treatment of ADHD in adulthood.

2.4 Assessment and Diagnosis of Adult ADHD

Many adults with ADHD have been diagnosed in childhood and continue to manage symptoms via treatment and behavioral changes. However, a portion of adults with ADHD do not receive a diagnosis during childhood for a variety of reasons and are referred for their first ADHD assessment during adulthood. Emergent evidence suggests that this first ADHD assessment in adulthood is occurring more frequently among women than men, possibly to make-up for underdiagnosis at earlier ages (London & Landes, 2021). An ADHD assessment for an adult can pose a number of challenges due to difficulty with the retrospective reporting of childhood symptoms and impairment that is required to establish a neurodevelopmental trajectory for the diagnosis of ADHD and differential diagnosis of ADHD as opposed to other disorders that can contribute to inattention in adults (e.g., anxiety, depression). In addition, ADHD symptoms may manifest differently in adulthood than in childhood, and ADHD rating scales or clinical interviews may not always fully capture the symptoms of adult ADHD. Moreover, a comprehensive ADHD evaluation is difficult to achieve in a standard 10–15-minute primary care office visit. An incomplete evaluation can result in both overdiagnosis (especially for men) and underdiagnosis (especially for women) (Hinshaw & Scheffler, 2014). Given these complexities, several considerations for assessing ADHD in adulthood are provided below.

2.4.1 Self-Report and Retrospective Recall of Symptoms

ADHD assessments typically involve, at the very least, a standardized self-report of symptoms and a clinical interview conducted by a trained provider. The self-report of ADHD symptoms is typically accomplished through an ADHD rating scale, such as the Adult ADHD Self-Report Scale, which includes multiple questions with Likert scale response options that reference the frequency of current ADHD symptoms. Clinical interviews can be utilized to ask about current and past symptoms, as well as if/how these symptoms are contributing to current functional impairments. As was established in the beginning of this chapter, a diagnosis of ADHD in adults requires the presence of five current symptoms of inattention and/or hyperactivity/impulsivity. Self-report scales and a clinical interview can be helpful in establishing an understanding of self-reported current symptoms and impairment. However, gaining insight into past symptoms can be more difficult. Criteria for diagnosing ADHD in adulthood require evidence of the presence of several symptoms (i.e., three or more symptoms) prior to age 12, yet adult recall of their childhood symptoms is often of questionable validity (Breda et al., 2020; Miller et al., 2010). The positive predictive power for ADHD based on adult retrospective recall of childhood symptoms is low, and only an estimated 27% of adults would be correctly identified as having ADHD utilizing recall of childhood symptoms alone (Breda et al., 2020). Adults with more severe current ADHD symptoms are more likely to accurately recall significant ADHD symptoms in childhood (Miller et al., 2010). Although not always possible, obtaining collateral information and school report cards or other historical documentation of childhood functioning is likely to improve the validity of retrospective symptoms and functioning. Because adult self-report of childhood symptoms can be questionable, integrating reports of childhood symptoms from caregivers and reviewing relevant documentation (e.g., report cards, teacher comments) may be useful to gain insight into the trajectory of ADHD symptoms across the lifespan/life course. More research into the validity of such supplemental reports and documentation, and their clinical utility, is needed.

2.4.2 Symptoms Relevant to Adult ADHD

As noted in the comparison between ADHD-related impairments in children versus adults, adults have more diverse domains in their life in which ADHD symptoms manifest. Therefore, assessments of ADHD in adulthood should include questions that comprehensively measure symptoms and areas of impairment that are specifically relevant for adults (Barkley, 2022). For example, clinicians may find it useful to inquire about attentional and organizational difficulties at work, impulsivity (e.g., speeding, running stoplights), or inattention while driving, or impulsive decision-making (e.g., quitting a job unexpectedly). A more expansive list of potentially relevant screening questions for assessing ADHD among adults, adapted from Barkley (2022), can be found in Table 2.1.

Special consideration may also be given to women presenting for an ADHD assessment, such that clinicians may choose to inquire about symptom presentation and areas of impairment that are particularly salient to women. These aforementioned areas of concern for women with ADHD include emotion dysregulation and relationship difficulties related to ADHD symptoms (e.g., partners are frustrated with inattention, impulsive decisions about entering or leaving relationships). Women with ADHD may present with more inattentive symptoms, and hyperactive/impulsive symptoms may reflect greater verbal overactivity (e.g., excessive talkativeness) compared to men with ADHD (Young et al., 2020). Understanding these nuances in ADHD presentation in adults, as well as gender differences among adults with ADHD, is important for the development of a comprehensive set of questions that clinicians can ask when assessing ADHD among adults.

Finally, considerations should be given to lifespan/life-course timing: Why is an adult presenting with concerns about ADHD now? Has this person pursued an ADHD diagnosis in the past, but did not receive one? Or is this the first attempt? One potential explanation for presenting for the first time in adulthood is that symptoms were previously managed via environmental and social supports, but environmental demands (or increased independence in adulthood) have now caused the symptoms to surpass manageability (Taylor et al., 2021). Relatedly, childhood ADHD symptoms may not have been detected earlier if they did not reach the level of

Table 2.1 Recommendations for assessing and diagnosing adult ADHD

Criteria	Description
DSM-5 criteria for diagnosis of ADHD in adults	Has 5 symptoms of hyperactivity/impulsivity and/or inattention Several symptoms of hyperactivity/impulsivity or inattention present before age 12 Symptoms occur in 2 or more settings Symptoms and impairment interfere with functioning and are not better explained by another psychiatric disorder
Recommended screening questions for adult ADHD	Do you. . . Start projects or tasks without reading the directions? Have difficulty managing work deadlines? Have difficulty organizing tasks and activities? Often forget appointments or obligations? Delay starting difficult or boring tasks? Have trouble keeping important documents, mail, or emails organized? Engage in impulsive driving (e.g., excessive speeding, running stop signs or yellow/red lights)? Make impulsive decisions?

clinical attention, possibly due to effective environmental management or protective factors (e.g., high IQ, social support, strong social skills). Because an ADHD diagnosis requires evidence of childhood symptoms, it is important to understand how childhood symptoms manifested and why a childhood diagnosis was not given. Clinicians may inquire about how this adult functioned as a child and may ask about strategies (e.g., parental scaffolding, accommodations from teachers) that helped manage symptoms during childhood. This line of questioning may also help to differentiate ADHD from other diagnoses, such as anxiety. Asking about past symptoms and methods of symptom management may reveal either a lack of historical symptoms or symptoms more aligned to another diagnosis (e.g., perfectionist tendencies more attributable to anxiety). Overall, a comprehensive evaluation of current and past symptoms, as well as associated impairments, is vital to yielding an accurate ADHD diagnosis in adulthood and to inform treatment considerations.

2.5 Treatment

ADHD in adults is most commonly treated with pharmacotherapy, followed by psychosocial interventions and combined treatment (i.e., pharmacotherapy and psychosocial intervention; NICE, 2018). While there is strong evidence to suggest the effectiveness of ADHD pharmacotherapies, as well as the efficacy of several psychosocial interventions for adult ADHD, there are notable differences and considerations in the management of ADHD in adulthood.

2.5.1 Medication Treatment

The leading psychopharmacological treatments for ADHD in adulthood, just as for ADHD in childhood, are stimulant medications. Stimulant medications for ADHD include methylphenidate, dexmethylphenidate, mixed amphetamine salts, lisdexamfetamine, and dextroamphetamine. Stimulant medications for ADHD exist in short-acting and long-acting forms. Non-stimulant medications that can also be used to treat ADHD include atomoxetine, guanfacine, and some antidepressants (e.g., bupropion, venlafaxine). A vast literature has detailed the efficacy and effectiveness of psychopharmacological treatments in managing the core symptoms of ADHD, with a meta-review finding that prescribed ADHD medications significantly reduced ADHD symptoms (Crescenzo et al., 2017). Another meta-review of pharmacological treatment identified short-acting stimulants as potentially more efficacious than long-acting stimulants (Moriyama et al., 2013). Both research and clinical practice have indicated that medication is usually the front-line treatment for ADHD in adulthood. Stimulant misuse and the prescription of ADHD medication for women are two areas of concern related to adults with ADHD that occur less frequently with respect to the treatment of children with ADHD.

2.5.1.1 Stimulant Misuse

Stimulant medication, though effective in treating ADHD in adulthood, may carry the risk of misuse. This is especially a concern among college students. Non-medical use of stimulants refers the use of a stimulant medication in any way that is not prescribed by a medical provider. The spectrum of misuse encompasses the misuse of one's own medication (e.g., insufflating medication, taking more than the prescribed dose) and the related phenomena of malingering for medication (e.g., intentionally feigning ADHD symptoms to be prescribed medication), as well as diverting one's prescribed stimulant medication to someone else. The most common motivations cited for stimulant misuse are academic or occupational performance enhancement or to obtain a high (Faraone et al., 2020).

College students are the demographic at highest risk for stimulant misuse, and adults with ADHD are more likely than those without ADHD to misuse a stimulant (Weyandt et al., 2014). Male college students with ADHD are more likely than female college students with ADHD to misuse stimulants, and college students who are members of a sorority or fraternity are at increased risk of stimulant misuse (Weyandt et al., 2014). An alarming 20% of adults who report misuse of a stimulant in the past year acknowledged fraudulently obtaining prescriptions from a medical provider by feigning symptoms (Faraone et al., 2020). As such, clinicians should be aware of the potentially related phenomena of adults malingering for stimulant medications that can be misused and/or diverted to others and the elevated risk of stimulant misuse among adults, especially male college students.

2.5.1.2 Pharmacotherapy and Women with ADHD

In terms of treating women with ADHD using pharmacotherapy, it is important to consider potential gender differences in medication efficacy, and efficacy and safety of medication use across the lifespan/life course. Interestingly, a systematic review of sex differences in ADHD medication efficacy revealed that there may be variations in which medications are most efficacious for women with ADHD (Kok et al., 2020). Evidence suggests that single-dose daily methylphenidate may be less efficacious for women than men with ADHD, and atomoxetine may be the optimal medication choice for treating ADHD among women (Kok et al., 2020).

Another consideration in treating women with ADHD is the effect of hormonal fluctuations during the progression of the menstrual cycle on the efficacy of medication. Although research is scarce on this topic, two studies have demonstrated that changes in estrogen and progesterone levels during the menstrual cycle may impact the stimulating effects and reduce efficacy of d-amphetamine among women (Justice & de Wit, 1999; White et al., 2002). The final female-specific consideration in the use of ADHD medication is the safety of taking medication during pregnancy and the postpartum period. ADHD is associated with several increased risks during pregnancy and delivery (e.g., preeclampsia, infection, cesarean section). However, these risks are not attributable to the use of prescribed ADHD medication (Kittel-Schneider et al., 2021). Both stimulant and non-stimulant medications for ADHD are considered safe for use by pregnant women. At present, there is little evidence that prescribed ADHD medication poses any risks to the child during pregnancy or breastfeeding (Kittel-Schneider et al., 2021).

2.5.2 Psychosocial Interventions

While pharmacotherapy is the leading treatment for ADHD in adulthood, there are several efficacious psychosocial interventions for treating core ADHD symptoms and related impairments. The majority of research on psychosocial interventions for ADHD in adulthood has focused on cognitive behavioral therapy (CBT) interventions (Fullen et al., 2020; Philipsen, 2012). CBT for adult ADHD has demonstrated efficacy and effectiveness in reducing the core symptoms of ADHD, as well as associated internalizing problems and low self-esteem (Fullen et al., 2020; Philipsen, 2012). These CBT interventions often include modules on psychoeducation, organizational and planning skills, and problem-solving approaches. There is evidence documenting the efficacy of both individual- and group-based CBT for adults with ADHD, and adults with ADHD report that peer-support in group-based interventions is subjectively helpful in maintaining motivation and feeling understood (Groß et al., 2019; Philipsen, 2012). In addition to CBT, mindfulness and dialectical behavior therapy are effective treatments for ADHD in adulthood (Fullen et al., 2020), although less research has focused on these interventions. Adults with ADHD respond positively to multimodal treatment, combining both medication and a psychosocial intervention, and this integrated treatment may be optimal for reducing ADHD symptoms and mitigating impairments (Geffen & Forster, 2018). Multimodal treatment allows for symptom management through medication, while simultaneously teaching and building skills to reduce distractibility, improve organization and planning, and foster self-efficacy (Geffen & Forster, 2018). Although psychosocial interventions are promising for adults with ADHD in general, there is currently no research investigating gender differences in response to psychosocial interventions. Given the aforementioned gender differences in symptom presentation and ADHD-related impairments, future research investigating gender as a moderator of psychosocial treatment outcomes is warranted.

2.6 Future Directions

Despite the increased understanding of ADHD in adulthood, there are still several aspects of ADHD among adults, and especially among women, that warrant further attention.

2.6.1 Expanding Knowledge of Adult ADHD Beyond 25 -Year-Old White Men

Similar to the need for additional research on women with ADHD, there is considerable need for the field to advance our knowledge of adult ADHD in non-White populations. For example, there are only two studies of adult ADHD in Black populations (Cénat et al., 2021) and race/ethnicity is very infrequently considered as a possible moderator of adult ADHD treatment outcomes. Similarly, how best to assess adult ADHD in diverse populations, and the extent to which CBT and other psychosocial interventions need to be tailored to higher frequency female-specific issues (e.g., hyper-verbal behaviors, relationship issues, motherhood, etc.), remain relatively open questions. Future research should consider how best to meet the treatment needs of diverse men and women with ADHD rather than assuming a "one size fits all" approach (Young et al., 2020).

Most of what we know presently about adult ADHD pertains only to young adults (younger than age 30). Thus, future research should consider how ADHD manifests itself across the lifespan/life course and the entire spectrum of adult development. For example, we know far more as a field about the impact of puberty on ADHD than we do about the impact of peri-menopause and menopause. Likewise, more research at the intersections of ADHD and various health conditions associated with adult aging (e.g., Alzheimer's disease and related dementias, diabetes) is warranted, especially because the management of many chronic diseases requires attentiveness to bodily states, behavior modifications, and medication schedules (McCoy, 2009).

2.6.2 ADHD in the Transgender, Non-Binary, and Gender Non-Conforming Population

In recent years, the increased visibility of transgender, non-binary, and other gender non-conforming (i.e., gender minority) individuals has highlighted the need for improved gender inclusivity in practically all fields of research and clinical practice. Improving understanding of the experience of ADHD and ADHD-related health care among transgender, non-binary, and gender non-conforming adults is especially important given that the severity of mental health symptoms presenting in other disorders (e.g., suicidality, anxiety, substance use) is higher among gender minority than among cis-gender individuals.

Only two studies to date have examined ADHD among gender minority individuals, and these studies are both descriptive in nature. The first study found that higher prevalence rates of ADHD exist in transgender and non-binary adults living in Australia (Bretherton et al., 2021). In the second, Thrower et al. (2020) conducted a systematic review to identify the prevalence of ADHD and autism spectrum disorder in individuals with gender dysphoria, but so few studies included the prevalence of ADHD in this population that no conclusions about the rate of overlap between ADHD and gender dysphoria could be drawn. While these two studies provide preliminary evidence that ADHD may be more prevalent in gender minority individuals, there is a substantial lack of understanding for how ADHD presents in these individuals. Given the noted gender differences in ADHD between cis-gender men and women and the difficulties these differences present in the assessment, diagnosis, and treatment of ADHD, research is needed to characterize the symptom profile of ADHD among gender minority individuals. Piloting diagnostic measures, such as the ADHD Adult Rating Scale, with gender minority individuals and measuring impairment in relation to ADHD symptom counts may help to generate new norms for gender minority individuals. Research examining how emotion dysregulation presents in gender minority individuals with ADHD will be important as the field continues to garner support for the centrality of emotion dysregulation in ADHD. Finally, treatment considerations and research trials examining the efficacy of medication and psychosocial treatments in gender minority individuals with ADHD is a key to providing comprehensive and useful treatments to this population. Because there is virtually no research available on ADHD among gender minority individuals, this is an area that should become a research priority in the coming years.

2.7 Conclusion

In the past two decades, it has become well established that adults can and do experience ADHD. This chapter synthesized the research documenting how ADHD among adults differs from ADHD among children, while simultaneously noting remaining gaps and inconsistencies, especially those related to gender differences.

The extant literature highlights that gender differences in adult ADHD can be found in the core symptoms of ADHD, rates of comorbidities, and features associated with the disorder. ADHD in adulthood is similar to childhood ADHD, yet distinctions can be found in the wider reaching domains of impairment seen in adult, compared to child, ADHD. Inattentive symptoms are typically more impairing than impulsive/hyperactive symptoms among adults with ADHD, and females with ADHD may find these inattentive symptoms especially impairing in their social relationships and during motherhood.

The assessment and treatment of ADHD among adults are complicated by these complexities. Moreover, it is quite challenging to make an accurate diagnosis in a 10–15-min primary care office appointment. ADHD in adulthood is most commonly treated with pharmacotherapy, followed by psychosocial interventions and combined treatment (i.e., pharmacotherapy and psychosocial intervention). While there is strong evidence to suggest the effectiveness of ADHD medications and the efficacy of several psychosocial interventions for adult ADHD, there are various issues that should be considered for the effective management of ADHD in adulthood. Finally, the field needs to improve our understanding of ADHD across the full spectrum of adult developmental trajectories, especially among racial/ethnic minority, cis-gender female, older, and gender minority adults (Table 2.2).

Table 2.2 A Comparison of adult ADHD features by gender

	ADHD in Women	ADHD in Men
Prevalence	3.2–4.49%	4.99–5.4%
ADHD presentation	ADHD-IN is most common presentation	ADHD-C and ADHD-HI are more common in males than females
Associated features and impairments	Low self-esteem, internalizing symptoms, self-harm behaviors, emotion dysregulation, social impairment, engagement in risky sexual behaviors, unplanned pregnancies	Externalizing symptoms, aggression, emotion dysregulation
Common comorbidities	Anxiety disorders, depression, autism spectrum disorder, borderline personality disorder, eating disorders	Anxiety disorders, depression, autism spectrum disorder, substance use disorders, antisocial personality disorder

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3 Autonomic Nervous System Functioning in ADHD

Alessio Bellato, Jan R. Wiersema, and Madeleine J. Groom

Abbreviations

ACC	Anterior Cingulate Cortex
ADHD	Attention Deficit/Hyperactivity Disorder
ANS	Autonomic Nervous System
CD	Conduct Disorder
CI	Confidence Interval
CNS	Central Nervous System
CSI	Cardiac Sympathetic Index
CVI	Cardiac Vagal Index
EDA	Electrodermal Activity
EEG	Electroencephalography
ENS	Enteric Nervous System
fMRI	Functional Magnetic Resonance Imaging
HF-HRV	High-Frequency component of Heart Rate Variability
HR	Heart Rate
HRV	Heart Rate Variability
LC	Locus Coeruleus
LC-NE	Locus Coeruleus-Norepinephrine
LF-HRV	Low-Frequency component of Heart Rate Variability
NE	Norepinephrine
ODD	Oppositional Defiant Disorder
OFC	Orbitofrontal Cortex
OR	Odds Ratio
PEP	Pre-Ejection Period
PFC	Pre-Frontal Cortex
PNS	Parasympathetic Nervous System
rMSSD	Square Root of the Mean of Successive Differences Between Inter-beat Intervals
RSA	Respiratory Sinus Arrhythmia
SCT	Sluggish-Cognitive Tempo
SNS	Sympathetic Nervous System
SRD	State Regulation Deficit
vmPFC	Ventro-Medial Pre-Frontal Cortex

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3.1 Introduction

Primary symptoms of attention deficit/hyperactivity disorder (ADHD) include age-inappropriate inattention, hyperactivity and impulsivity, and socioemotional and cognitive difficulties (Faraone et al., 2021). ADHD increases the risk of educational underachievement, poorer quality of life and well-being, and affects around 5% of children and adolescents worldwide, persisting into adulthood in most cases (Posner et al., 2020). It has been proposed that primary and secondary symptoms and features that characterize ADHD may partly arise from dysregulated autonomic arousal. Investigating autonomic functioning in ADHD is an important (but under-

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researched) topic that could prove helpful in developing more efficient and valid assessment and intervention tools for ADHD.

In this chapter, we will introduce the concept of autonomic arousal and discuss the involvement of the autonomic nervous system in multiple processes that are affected in ADHD. After presenting several theoretical frameworks that have proposed arousal dysregulation to have a central role in ADHD, we will present evidence (both in the form of systematic reviews or meta-analyses and individual empirical studies) that has been found to support these models. We will then discuss evidence of the association between autonomic dysregulation and other psychiatric or psychological conditions that often co-occur with ADHD, and we will analyze the effects of pharmacological and nonpharmacological interventions on autonomic functioning in people with ADHD. Lastly, we will provide suggestions for clinicians and researchers to highlight the importance of working, in the next few years, toward clarifying the role of dysregulated autonomic arousal in ADHD and identifying novel interventions (or strengthening the existing) to improve the quality of life and well-being of people with this neurodevelopmental condition.

3.2 Arousal and the Autonomic Nervous System

Arousal can be defined as the set of mechanisms that characterize wakefulness, i.e., the state of being awake in comparison to sleep, but it also indicates the neural, behavioral, or physiological state of an individual in response to sensory stimulation (Lacey, 1967). These mechanisms are governed by interactions between ascending brain networks (which project to the cerebral cortex and stimulate cortical activation in response to somatic, visceral, or sensory inputs) and descending networks (which project to the spinal cord and elicit motor behaviors or temporary changes in functioning of bodily organs) (Jones, 2003). The arousal state of an individual at a given time is therefore influenced by sensory stimulation (incoming from the surrounding environment or internally) and conscious attempts to self-regulate in a specific context or situation. Being able to regulate arousal and, consequently, behavior, quickly and efficiently according to situational demands, is an important skill that starts developing in infancy and continues until young adulthood, in parallel with the development of frontal brain systems involved in learning, information processing, and self-regulation.

Among the different systems involved in arousal, the autonomic nervous system (ANS) is responsible for automatic (i.e., involuntary) modulation of physiological processes, including heart rate (HR), blood pressure, pupil size, bowel and bladder function, sexual organs' function, thermoregulation, and sweating. Being part of the peripheral nervous system, the ANS is comprised of three main anatomically distinct systems (Karemaker, 2017):

– The sympathetic nervous system (SNS) is active in situations that necessitate fast allocation and mobilization of energetic resources, eliciting 'fight or flight' responses. It produces excitatory effects on bodily systems, such as increases in HR or blood pressure, and pupil dilations.
– The parasympathetic nervous system (PNS) is responsible for 'rest and digest' responses aimed at preserving and maintaining energetic resources for long periods of time. Activation of the PNS produces slower and more variable HR, and pupil constrictions.
– The enteric nervous system (ENS) functions slightly independently from the SNS and the PNS, and it mainly regulates digestive processes through reflex pathways; for example, it is responsible for contraction and relaxation of muscles in the digestive system.

Although they seem to have antagonistic functions, the SNS and the PNS act in a synergistic way to regulate autonomic arousal and help the organism to reach or maintain an optimal state characterized by adequate HR, respiratory behavior, levels of glucose and oxygen in the blood, body temperature, perspiration, and salivation, in line with environmental demands and internal states (Quadt et al., 2022). Therefore, both the SNS and the PNS are active during most of our everyday life (for example, they differently contribute to the inspiration and expiration phases of the respiratory cycle) and not only during those situations that require a 'fight-or-flight' or a 'rest-and-digest' response (Wehrwein et al., 2016).

3.2.1 Structural Components of the Autonomic Nervous System

The different functions of the SNS and the PNS partly derive from differences in their structural components. Although most bodily systems and organs are innervated by both the SNS and the PNS, the preganglionic cell bodies of the SNS are mainly found in the thoracolumbar region, while those of the PNS are found in regions where cranial and sacral nerves leave the CNS (Karemaker, 2017). The vagus is the most important nerve in the PNS (making up about 75% of the whole branch), primarily innervating the lungs and the heart, besides other regions involved in gastrointestinal and endocrine mechanisms (Waxenbaum et al., 2022). Another important difference between the SNS and the PNS is in the type of neurotransmitters involved in each branch. While acetylcholine is the main neurotransmitter of presynaptic neurons of both SNS and PNS, postsynaptic transmission involves acetylcholine in the PNS and norepinephrine (NE) in the SNS (Gibbons, 2019).

As mentioned earlier, the ENS functions slightly independently from the SNS and the PNS. In fact, although the ENS receives sympathetic and parasympathetic input originating from the spinal cord and transmits sensory information to the central autonomic networks through the same pathways, its subcomponents directly (and independently from the SNS and the PNS) affect gastrointestinal function. Different neurotransmitters, including acetylcholine and serotonin, are involved in functioning of the ENS (Gibbons, 2019).

Several regions, within the CNS, are responsible for integrating sensory and autonomic sensations, and promoting behavioral responses aimed at regulating arousal based on the situation and the state of an individual (see Quadt et al., 2022, for an overview of the central autonomic network). The hypothalamus, for example, is responsible for regulating and controlling homeostatic and endocrine processes, such as body temperature and sleep, while brainstem centers are primarily involved in controlling cardiovascular and respiratory functions. Other regions – parts of the limbic system – are responsible for processing the sensory information incoming from the body, recoding these into emotional meaning, and promoting cognitive, behavioral, and emotional responses. Specifically, the anterior cingulate cortex (ACC) is interconnected with several other areas, within the prefrontal cortex, and with insula, amygdala, hypothalamus, and brainstem regions, and therefore plays a key role in regulating autonomic arousal, especially by modulating activity in the PNS.

Among the several structures that are involved in arousal, the locus coeruleus (LC) is a small group of norepinephrinergic neurons situated in the pons (within the brainstem). Having bidirectional connections with prefrontal regions (including the ACC, the orbitofrontal cortex (OFC) and the ventromedial prefrontal cortex (vmPFC)), the insula and the limbic system, and receiving peripheral autonomic signals from the vagus nerve through the nucleus of the solitary tract, the LC has been proposed to play an important role in arousal regulation, attention allocation, and information processing (Aston-Jones & Cohen, 2005; Aston-Jones & Waterhouse, 2016; Aston-Jones et al., 2000, 2007; Bast et al., 2018; Sara & Bouret, 2012). Specifically, the LC is the main source of NE in the cortex, and by modulating the availability of dopamine and glutamate in frontal regions (Mather et al., 2016), it influences a range of cognitive functions, including perception, memory, working memory, sustained attention, and task switching (Sara & Bouret, 2012).

As we will be discussing in more detail in the chapter, core features of ADHD seem to indicate altered functioning of the ANS and weaker arousal regulation. Identifying which specific aspects of arousal regulation are affected in ADHD and linking these difficulties with specific alterations in the functioning of brain regions and systems within the ANS and the CNS may prove helpful for targeting those impairments more effectively.

3.2.2 Indices of Autonomic Nervous System Functioning in Humans

While in animals the direct measurement of ANS functioning is possible and is widely used (by measuring changes in electrical activity of cervical or abdominal neurons), in humans these techniques are too invasive; therefore, activity in the ANS is measured by focusing on changes in peripheral indices of bodily functioning. For instance, analyzing the concentration of plasma catecholamines or salivary cortisol has been used to obtain a global index of activity of the SNS and, overall, autonomic arousal. Similarly, changes in skin conductance measured via electrodermal activity (EDA) reflect constrictions and dilations of blood vessels underneath the surface of the skin, and sweat glands secretion, which are under sympathetic influence. Conversely, due to being innervated by both the SNS and the PNS, the pupil is under sympathetic and parasympathetic control.

Mean HR – the average number of beats per minute – is considered a general measure of arousal (with higher HR indicating increased arousal). However, investigating heart rate variability (HRV) – fluctuations in HR over time – is usually preferred since it allows clinicians and researchers to obtain separate estimates of sympathetic and parasympathetic influence on HR. Although innervated by both SNS and PNS neurons, the heart is in fact predominantly under parasympathetic inhibitory influence via the vagus nerve, and increased parasympathetic activity is associated with increased HRV and HR deceleration (Laitio et al., 2007).

Different measures can be obtained by analyzing time and frequency domains, or nonlinear characteristics of HRV (see Shaffer & Ginsberg, 2017, for a comprehensive overview), including:

- Square root of the mean of successive differences between inter-beat intervals (rMSSD), which is considered a general measure of HRV.
- Low-frequency component of HRV (LF-HRV; 0.04–0.15 Hz), which reflects combined sympathetic and parasympathetic influence, but is thought to mainly reflect the activity in the SNS.
- High-frequency component of HRV (HF-HRV; 0.15–0.40 Hz), which mainly reflects parasympathetic influence on the heart and is influenced by respiration rate.
- Low-frequency/high-frequency (LF/HF) ratio, which, although controversially, is thought to reflect the balance between activity in the SNS and the PNS.
- Respiratory sinus arrhythmia (RSA), which reflects the difference between vagal activity during inspiration and expiration and is usually interpreted as an index of parasympathetic cardiac control.
- Cardiac sympathetic index (CSI) and cardiac vagal index (CVI, Toichi et al., 1997), two nonlinear measures of sympathetic and vagal functions, respectively.

Clarifying the associations between HR, EDA, and pupil size, to determine how activity in the SNS and the PNS trigger changes in these peripheral indices of bodily functioning, has been attempted for several decades. Based on the previous literature, increased activity in the PNS seems associated with slower HR and pupil size constrictions, while activity in the SNS triggers increases in EDA and pupil dilation (Bond et al., 1974; Colman & Paivio, 1969; Tursky et al., 1969; Wang et al., 2018). However, concurrent activation of the SNS and the PNS, in certain situations of everyday life, has been reported. During conditions characterized by greater cognitive challenges requiring effort allocation, SNS-driven responses (e.g., increased pupil size and EDA) have been observed, and they are interpreted as a sign of increased cognitive workload (in fact, increased release of NE may be required to allocate more attentional resources when the task becomes difficult; Sara & Bouret, 2012). In parallel, PNS-mediated HR decelerations have also been observed, probably reflecting efforts to regulate arousal, to respond quickly, and perform accurately (Jennings et al., 1998; Libby et al., 1973).

Previous studies highlighted associations between activity in the LC-NE system and changes in peripheral indices of autonomic arousal, suggesting that some of these indices may be used to track functioning of the LC-NE system. For example, increased neuronal activation of the LC has been found to increase HR by inhibiting vagally mediated parasympathetic control of the heart (Samuels & Szabadi, 2008; Wang, et al., 2014). Similarly, during cognitively effortful tasks and in response to novel or emotionally intense stimuli (but also at rest), increased neuronal activity in the LC is associated with pupil dilations (Costa & Rudebeck, 2016; Murphy et al., 2014). Lastly, increased activation of prefrontal and limbic systems (e.g., medial PFC, ACC, and amygdala), which are interconnected with the LC, has been associated with increased parasympathetic-driven HRV (McKlveen et al., 2015; Thayer, et al., 2012).

All these findings seem to suggest that when the LC is active, energy mobilization may be elicited, resulting in increased EDA, accelerated heart rate, and pupil dilation. Prefrontal and limbic structures may be responsible for regulating activity of the LC (i.e., promoting energy mobilization or inhibiting LC activity), based on the nature of the situation and environmental demands, e.g., promoting LC activation during low arousal states and reducing LC activity in response to hyperarousal. We will explore these ideas further in the next few paragraphs.

3.2.3 The Role of the Autonomic Nervous System in Cognition and Self-Regulation

The involvement of central and peripheral autonomic centers in cognition and attention has been investigated for over a century. The evidence of structural connections between frontal, limbic, and brainstem areas is in fact likely to suggest a coordinated role of these systems in arousal regulation. In 1908, Yerkes and Dodson hypothesized an inverted U-shaped relationship between autonomic arousal and performance, and proposed that either reduced or heightened arousal would negatively impact performance to certain activities and tasks, but in different – if not opposite – ways (Fig. 3.1). Specifically, Yerkes and Dodson (1908) proposed that a state characterized by low arousal would be associated with difficulties in maintaining attention and vigilance, and sleepiness, while excessive arousal would lead to increased distractibility, exploratory behaviors, and stress. More recently, the possibility of using advanced methods for investigating autonomic arousal in relation to cognition (including precise measurement of neural and physiological responses at the millisecond level) has proven helpful to partly clarify the role of central and peripheral autonomic systems (including the LC-NE) in behavior, attention, and cognition.

Aston-Jones and Cohen (2005) proposed that the LC functions in two main modes: *tonic* and *phasic*. When we are awake but not involved in any particular activity, the LC is predominantly in the tonic mode: its neurons fire at low frequencies (usually in the range of 1–3 Hz; less than 2 Hz during quiet waking and around 2–3 Hz during active wakefulness) and NE is regularly and constantly released in cortical regions (Howells et al., 2012). This facilitates *exploration* of the environment and supports the maintenance of a general state of alertness that promotes effective searching for rewarding stimuli in the environment (Berridge & Waterhouse, 2003). However, being interconnected with many subcortical and cortical centers (including superior colliculi,

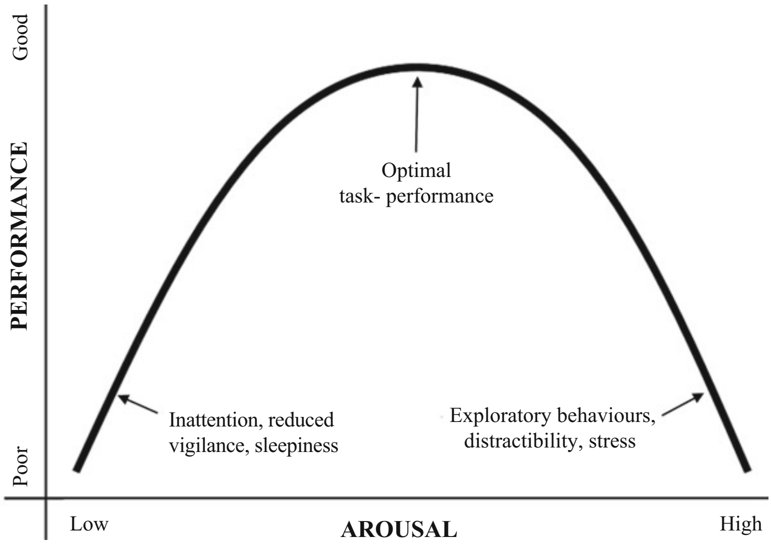

Fig. 3.1 Graphical representation of the Yerkes & Dodson inverted-U curve

thalamus, ventral striatum, amygdala, ACC, and anterior insula), the LC is also involved in rapidly directing and orienting attention toward sensory information in the environment (e.g., novel or salient stimuli). When a stimulus reaches perceptual awareness (for example, we hear a door slam, or see a dog turn the street corner and point to us), LC neurons display a phasic burst of activity at higher frequencies (in the range of 10–20 Hz), which causes a consequent release of NE and sympathetic activation (e.g., HR acceleration, pupil dilation, and increased EDA; Sara & Bouret, 2012; Orekhova & Stroganova, 2014), which facilitates orienting of attention toward that stimulus to determine if, based on the situation, it should be further processed or ignored.

Partly resembling Yerkes and Dodson's inverted-U curve, it has been proposed that phasic activation of the LC is dependent on tonic baseline activity (Berridge & Waterhouse, 2003). For example, low tonic activation of the LC characterizes states of drowsiness and reduced vigilance. If one is asked to perform a cognitive task in a tonic hypoarousal state (for instance, after having worked for many hours and feeling tired and drowsy), it is likely that LC neurons will not show sufficient phasic reactivity to effectively orient attention to task-relevant sensory information. In these situations, arousal regulation strategies should be adopted to voluntarily increase tonic activity in the LC and facilitate processing of information that is relevant for successful task completion. Conversely, when in a hyperarousal state (e.g., before a job interview or after experiencing a strong emotion), the LC may show nonspecific phasic responsivity to different sensory stimuli in the environment, causing distractibility and sensory hypersensitivity, which would be detrimental for performance (Howells et al., 2012). In these situations, arousal regulation strategies should be adopted too, but this time with the intent of re-establishing an optimal physiological state by reducing arousal.

The LC-NE system is therefore likely to play an important role in arousal regulation and, specifically, in maintaining an optimal level of alertness and vigilance (so that attention can be easily and quickly oriented toward novel incoming sensory information) and supporting sustained attention (so that only information that is relevant in a specific situation is prioritized and further processed to successfully complete a certain task). Moreover, being able to quickly transition between exploratory (tonic) and exploitative (phasic) states is crucial not only to remain vigilant and ready to adapt behavior to new situations and incoming sensory information but also to maintain attention toward context-relevant sensory information to execute tasks accurately and efficiently (Aston-Jones & Cohen, 2005). Lastly, effective functioning of prefrontal structures (which exert top-down control on the LC) is needed for being able to modulate arousal during situations characterized by either excessively reduced or exaggerated arousal.

Multiple theoretical models have been developed to clarify the involvement of autonomic systems, especially those responsible for cardiac control through the vagus nerve, in arousal and self-regulation, social functioning and psychological well-being (Porges, 2007, 2009; Thayer & Lane, 2000; Thayer et al., 2012). According to the Porges' polyvagal theory and the Thayer and Lane's neurovisceral integration model, prefrontal brain systems are responsible for the evaluation of positive and negative characteristics of a situation (e.g., costs vs benefits; rewards vs dangers). Evaluating a situation as safe promotes self-regulation and engagement in social behaviors, which is evolutionarily adaptive. Conversely, when a certain situation is perceived unsafe or dangerous, more primitive behaviors emerge, including exaggerated stress response and anxiety, excessive distractibility, aggressive behaviors, or immobilization and social withdrawal. This is reflected in an imbalance in PNS and SNS functioning (specifically, excessive sympathetic and reduced parasympathetic activity), which may be adaptive in the short term in response to the perceived danger (providing the individual with adequate energy to escape from the dangerous situation), but it is maladaptive in the long term (especially if increased levels of anxiety and stress are maintained over time). The ability to restore the balance between PNS and SNS functioning in response to negative events and situations is influenced by activity in central and peripheral autonomic systems and is reflected in vagally mediated HRV (Critchley, 2005; Thayer et al., 2012). Reduced HRV, which is a sign of weaker vagal control, has been associated with poorer emotional functioning and reduced self-regulation, and has been proposed to be a transdiagnostic marker of psychopathology and reduced social functioning (Beauchaine & Thayer, 2015).

3.2.4 Development of the Autonomic Nervous System in Humans

The ANS undergoes important structural and functional changes in the pre- and postnatal period. Although not functional until birth, the vagus nerve is the first component of the ANS to develop during the fetal period, followed by components of the sympathetic branch and the remaining parasympathetic system (Mulkey & du Plessis, 2019). Primitive self-regulation strategies, which are used to reach and maintain an optimal physiological state, can already be seen in the first three months of life, but are dependent on external support; for example, infants can calm down, after experiencing stress, with a pacifier or when hugged by parents. As connectivity between frontal, limbic, and brainstem autonomic systems gradually increases throughout development (consequently, increased control on the ANS can be exerted), the infant becomes more and more able to adopt independent and more elaborated strategies of arousal regulation. Parasympathetic influence on the heart gradually increases in the first years of life, resulting in progressively increased HRV from infancy to childhood (Harteveld et al., 2021).

According to the developmental neuroconstructivist approach (Karmiloff-Smith, 2009), human development is influenced by interactions between specializing bodily structures and systems, and the environment. Therefore, it could be speculated that atypical development and functioning of central and peripheral autonomic systems, early in life, may cause difficulties in self-regulation in response to stressors. This might undermine the ability to pay attention to and extract relevant information from sensory stimuli in the environment, further limiting the maturation of those brain systems involved in arousal- and self-regulation later in life (Mulkey & du Plessis, 2019). Similarly, it could also be that functioning of typically developing central and peripheral autonomic systems may be negatively impacted by environmental stressors during infancy and early childhood, and this may alter the developmental trajectories of brain systems involved in arousal and behavior regulation during the late childhood and adolescence.

Although the focus of this chapter is not discussing the influence of genetic and environmental factors on the development of adult-like arousal- and self-regulation strategies, it would be important to note that these depend on full maturation of structural and functional connectivity between the brainstem, the limbic system, and frontal regions. In fact, as theorized in the vertical-integrative model by Geva and Feldman (2008; 2017), atypical prenatal development of brainstem structures (including the LC) might lead to physiological dysregulation and atypical sensory processing in the first year of life. Consequently, atypical maturation of fronto-limbic connectivity is likely to lead to difficulties in arousal regulation, physiological and emotional distress during infancy and later in life, with negative effects on cognitive and socioemotional development.

3.3 Theoretical Models of Autonomic Nervous System Dysfunction in ADHD

For at least three decades, authors and researchers in the field of ADHD have been working toward developing theoretical models that can explain the core domains of ADHD symptomatology, namely, inattention, hyperactivity, and impulsivity. For example, it has been proposed that deficits in executive functioning (particularly, response inhibition), due to structural and functional alterations in fronto-striatal and fronto-parietal brain systems, underlie ADHD symptomatology (Barkley, 1997). This model is supported by empirical evidence showing that deficits in vigilance, response inhibition, working memory, and planning are found in children, adolescents, and adults with ADHD (see Willcutt et al., 2005, for a meta-analysis). However, Barkley's model cannot explain the heterogeneity of ADHD symptomatology, especially in relation to hyperactivity and other symptomatologic domains. In addition, executive functioning deficits are not universal or specific for individuals with ADHD, indicating that these deficits are neither necessary nor sufficient to explain ADHD (Willcutt et al., 2005). Finally, ADHD symptomatology and performance deficits (e.g., in executive functioning) have been shown to be strongly context-dependent (Sonuga-Barke et al., 2010; van der Meere, 2005; Wiersema et al., 2006a, b).

The fact that dysregulated arousal plays a central role in ADHD is the core idea of the state regulation deficit (SRD) model, which emphasizes the dynamic, rather than the fixed, nature of ADHD and especially the role of arousal in determining cognitive and performance deficits (Sonuga-Barke et al., 2010; van der Meere, 2005). The SRD model has been developed in the last few decades and is founded on the cognitive-energetic model by Sanders (1983). The cognitive-energetic model states that information processing relies on different steps, and it is influenced by the level of arousal and activation (which conceptually resemble phasic and tonic arousal, as in the Aston-Jones and Cohen's model), with more effort required to effectively process information in suboptimal conditions. Within the SRD model, the core idea is that people with ADHD struggle to regulate their arousal state when required to keep performance at a certain level, leading to hypo- or hyperarousal but with most evidence pointing to more proneness to hypoarousal (Johnson et al., 2009; Sergeant, 2000, 2005; Sonuga-Barke et al., 2010; van der Meere, 2005; van der Meere et al., 2010; van der Meere & Sergeant, 1988; Wiersema et al., 2006a, b). For example, it has been demonstrated that modulating the stimulus presentation rate (argued to influence tonic arousal levels), during sustained attention and response inhibition tasks (e.g., Go/No-Go), affects performance accuracy and response times more strongly in people with ADHD compared to neurotypical controls, with slower responses during slow-event rate conditions and less accurate performance during fast-event rate conditions observed in people with ADHD (see Metin et al., 2012, for a meta-analysis). This is in line with the inverted-U association between arousal and cognitive performance proposed by Yerkes and Dodson (1908). Moreover, dysregulated tonic arousal may partly explain fluctuations in performance, e.g., intraindividual reaction time variability, widely reported in ADHD (Kuntsi & Klein, 2012; Metin et al., 2016).

In relation to the neurobiological correlates of arousal dysregulation in ADHD, it has been proposed that brain hypoarousal (for example, predominance of slow-wave neural activity and decreased fast-wave activity in frontal regions, and reduced amplitude of electrophysiological markers of information processing and response inhibition) and autonomic dysfunction (specifically, dysfunction in the LC-NE system) are likely to explain core symptoms of ADHD, including fluctuations in vigilance and difficulties in regulating behavior based on contextual demands (Martella et al., 2020). Although discussing theoretical models of brain hypoarousal and presenting studies that investigated indices of brain functioning (e.g., EEG or fMRI) in ADHD would be relevant and crucial for understanding the pathophysiology of this condition, in this chapter we will not focus on those, since they have already been extensively covered in the literature; see, for example, Barry and Clarke (2013), Barry et al. (2003), Bozhilova et al. (2018), Buyck and Wiersema (2014, 2015), Geissler et al. (2014), Kuntsi and Klein (2012), Martella et al. (2020), Metin et al. (2015), and Sander et al. (2015). Instead, we are presenting an overview of theoretical models and empirical evidence relating to autonomic dysfunction in ADHD.

Some authors have proposed that neurons in the LC-NE system may fire at slightly lower frequencies in people with ADHD, causing chronically reduced tonic release of NE and reducing phasic responsivity to sensory information (Aston-Jones et al., 2000, 2007; Howells et al., 2012). This is likely to be reflected in inattention and reduced vigilance, and difficulties in reaching and maintaining an adequate level of arousal during cognitive tasks, which are indeed commonly seen in ADHD. However, it has also been proposed that, at least in some situations, excessive activation of the LC may lead to exaggerated tonic release of NE in the PFC, augmenting distractibility and undermining the ability to efficiently respond to context-relevant information and ignore irrelevant information (Konrad et al., 2006; Mefford & Potter, 1989; Pliszka et al., 1996; Rowe et al., 2005). This could explain the fact that, for example, fast-paced activities usually lead to hyperexcitation and less accurate performance in people with ADHD.

An idea that attempted to combine these two opposite views, within the SRD model, has recently emerged (Drescher et al., 2021). It has been proposed that dysregulated tonic LC activity, in ADHD, may cause both hypo- and hyperarousal, and this may be dependent on the context. Miller and Prevatt (2020), for example, investigated the relationship between hyperactivity and inattention in the general adult population and found that more severe attentional problems characterized adults displaying either hypo- or hyperactivity, while those in the middle of the hyperactivity continuum displayed less attentional problems. Both reduced functioning of the ANS and weaker ability to regulate autonomic arousal may indeed explain different components of ADHD symptomatology. Motor hyperactivity and restlessness, for example, might be the strategies adopted to regulate brain and autonomic hypoarousal (Geissler et al., 2014), while difficulties in downregulating autonomic arousal during situations characterized by stress or when reward exploitation is delayed may lead to excessive autonomic and physiological arousal (Barkley, 2010; Sonuga-Barke et al., 2010). Both tonic hypo- and hyperarousal in ADHD are likely to affect phasic responsivity of the LC, with detrimental effects on cognitive performance and behavior (Drescher et al., 2021).

Due to the small size of the LC, its location (deep in the brainstem) and the fact that it is difficult to directly record LC activity in humans, validating models of dysregulated functioning of the LC in ADHD has proven quite difficult. For example, only one study, to our knowledge, has effectively observed structural alterations in brainstem autonomic centers associated with

ADHD (Johnston et al., 2014), with reduced size of an area thought to correspond to the LC reported in adults with ADHD compared with their neurotypical peers. Moreover, to our knowledge, there are no published studies using fMRI to measure the LC activity in people with and without ADHD. We hope that currently ongoing studies and future studies that aim to directly investigate functioning of the LC in people with ADHD will be able to clarify the involvement of this structure in the ADHD pathophysiology.

Most of the studies in the literature have focused on peripheral or indirect indices of autonomic arousal and activity in the LC-NE system and compared groups of people with and without ADHD on such measures. In the next paragraphs, we will present a comprehensive overview and discussion of these studies.

3.4 Evidence of Dysregulation of the Autonomic Nervous System in ADHD

Some symptoms of nonpsychiatric medical conditions, commonly found in ADHD, are likely to reflect or be associated with autonomic dysfunction. For example, obesity, sleep disorders, allergies, asthma, problems regulating appetite, diabetes, hypertension, and psoriasis are common in ADHD (Faraone et al., 2021). Infants later diagnosed with ADHD have also been found to show sleep problems (Vélez-Galarraga et al., 2016), increased negative emotional reactivity (Isaksson et al., 2012), and reduced exploratory behaviors (Auerbach et al., 2004, 2008), in line with the idea that dysregulated autonomic arousal is likely to be present even before more ‘classic’ symptoms of ADHD become evident. This idea is supported by studies (e.g., Fortier et al., 2013) that demonstrated an association between genetic susceptibility to dysregulated physiological responsivity to stress and attentional problems, oppositional defiant behaviors, and executive functioning. Moreover, structural and functional alterations in central and peripheral autonomic systems have been reported in ADHD. For example, abnormalities in fronto-striatal, fronto-parieto-temporal, and fronto-limbic networks have been observed (Rubia et al., 2014), together with alterations in noradrenergic and dopaminergic neural pathways that are likely to form part of the LC-NE system (Cortese et al., 2018; Faraone & Larsson, 2019). Lastly, studies have observed, in people with ADHD, higher daytime sleepiness (Cortese et al., 2006), altered circadian rhythms (Imeraj et al., 2012), and behavioral signs of reduced vigilance and alertness (e.g., increased intraindividual reaction time variability; Kofler et al., 2013) across multiple experimental paradigms, but especially during slow-paced and monotonous cognitive tasks (Metin et al., 2012). Similarly, increased reported daytime sleepiness has also been found in adults from the general population who reported increased levels of ADHD traits, especially inattention (Ito et al., 2017).

These findings seem to highlight the presence of autonomic dysregulation in ADHD; many studies attempted to further clarify this association by investigating peripheral indices of functioning of the ANS – such as cortisol and salivary alpha-amylase, HR, EDA, and pupil size – and will be discussed now.

3.4.1 Salivary Alpha-Amylase and Cortisol

Reduced salivary alpha-amylase and cortisol, markers of activity of the SNS and the hypothalamic–pituitary–adrenal axis, have been found in children with ADHD (see, for example, Anesiadou et al., 2021; Angeli et al., 2018; Blomqvist et al., 2007; Isaksson et al., 2012, 2013; King et al., 1998). However, other studies did not find any difference between children with ADHD and controls on this measure (Imeraj et al., 2012) or found increased cortisol in ADHD (Krahel et al., 2021; Ramos-Quiroga et al., 2016). Chang et al. (2021) recently investigated differences in blood and saliva cortisol in young people with and without ADHD by conducting a meta-analysis on 19 studies (comparing 916 young people with ADHD and 947 neurotypicals). They found reduced cortisol levels in young people with ADHD compared to their peers without ADHD (Hedge's g = 0.6; 95% CI = [0.21; 1.14]), and this was especially true for samples collected in the morning compared to other times during the day.

3.4.2 Peripheral Indices of Autonomic Nervous System Functioning

3.4.2.1 Evidence from Systematic Reviews and Meta-analysis

Many studies have investigated peripheral indices of ANS functioning (such as HR, EDA/skin conductance, and pupil size) in ADHD at least since the early 1980s. These studies have been summarized and analyzed together in several systematic reviews and meta-analyses, which will be presented now.

Rash and Aguirre-Camacho (2012) performed the first systematic review of the literature investigating parasympathetic-related cardiac vagal control in ADHD. They identified only six eligible studies (some of dubious quality and with mixed findings) and concluded that unmedicated children with ADHD are likely to show reduced cardiac vagal control compared to neurotypicals. A few years later, this systematic review was complemented with a meta-analysis (Koenig et al., 2017), with the intent to clarify if reduced resting-state HF-HRV (an index of cardiac vagal control) characterize people with ADHD compared to neurotypical controls. The search, conducted up to the sixth of January 2015, resulted in 10 studies included in the narrative review and eight independent studies included in the meta-analysis. In contrast with findings of Rash and Aguirre-Camacho (2012), the meta-analytic comparison of 317 individuals with ADHD and 270 controls, conducted by Koenig and colleagues, did not show a significant difference between the two groups in resting-state HF-HRV (Hedge's g = 0.06, 95% CI = [−0.18; 0.29]), and this effect did not change when analyzing children/adolescents and adults separately.

Following these mixed findings, Robe et al. (2019) investigated task-related vagally mediated HRV in ADHD. Their systematic search of the literature resulted in 13 studies eligible to be included in a meta-analysis. The authors found significantly reduced vagally mediated HRV in unmedicated children and adolescents with ADHD compared to neurotypical controls (Hedge's g = 0.20; 95% CI = [0.01; 0.40]). They also observed that this effect was larger in those with ADHD without comorbidities compared to those with comorbidities, who may be displaying more heterogeneous patterns of ANS functioning. A broader systematic review of the literature was recently conducted (Bellato et al., 2020) to investigate different measures of ANS functioning in individuals with and without a diagnosis of ADHD. The last search for this systematic review was done in December 2018 and resulted in 55 studies reporting data on electrodermal activity (32 studies), HR (35 studies), and pupil size (four studies). Although quite heterogeneous, findings showed evidence of dysregulated arousal in individuals with ADHD (more often in the direction of hypoarousal than hyperarousal), and this effect was primarily found during resting-state and during cognitive tasks that required sustained attention and response regulation (especially in relation to EDA). Inconsistent findings emerged from studies that used tasks involving processing of salient or rewarding or socioemotional stimuli. In the last few years (since the last search for the systematic review by Bellato and colleagues was conducted), new studies were published and will be presented in the next few paragraphs.

3.4.2.2 Evidence from Recent Studies on Cardiovascular Measures and Electrodermal Activity

Resting State

Some studies measured autonomic arousal during resting-state in people with and without ADHD. Gomez et al. (2021) found significantly reduced activity of the PNS at rest (indexed by reduced HF-HRV) in boys with ADHD compared to neurotypicals, with reduced HF-HRV being associated with reduced sensory processing. Kvadsheim et al. (2020) investigated the association between resting-state vagal activity (HF-HRV) and self-reported emotion dysregulation in adolescents with ADHD. In line with findings from Gomez et al. (2021), lower resting-state parasympathetic functioning was found in ADHD, and it was associated with increased emotional dysregulation and reduced use of effective strategies for emotion regulation. When applying a novel graph theoretical methodology to resting-state cardiac data, Kvadsheim et al. (2022) found reduced variability in interbeat intervals in adolescents with ADHD compared to controls, and this was in line with their previous findings and Gomez et al.'s findings of reduced resting-state parasympathetic function in ADHD. Lastly, based on their previous findings of reduced resting-state blood pressure in children with ADHD (published in Meyer et al., 2017), Schulz et al. (2021) were interested in understanding if these alterations were still present 10 years later. They found that, in young adults, such difference was not present anymore; it should be noted, though, that the final sample of young adults was only one-fourth of the initial sample. Considering other studies that found a correlation between reduced regulation of pulse in response to an orthostatic challenge (i.e., switching from standing to a supine position) and higher ADHD traits in preschoolers (Casavant et al., 2012), and the reported changes in ADHD symptomatology between childhood/adolescence and adulthood (Faraone et al., 2021), it would be interesting to study developmental changes in ANS functioning at rest, both in neurotypical and ADHD populations.

Cognitive Tasks and Reward Processing

Considering that the nature of a task or the valence of stimuli used during a certain activity or paradigm may affect autonomic arousal and, consequently, performance, attempts have been made to clarify if and how experimental conditions of different nature (including but not limited to resting-state) affect autonomic arousal in ADHD. Using nonlinear indices of HRV (the CSI and the CVI, Toichi et al., 1997), Bellato et al. (2021b) found evidence of dysregulated functioning of the ANS in children and adolescents with ADHD, but only in specific experimental conditions. Specifically, indices of hypoarousal and reduced functioning of the SNS were found during resting-state and during a passive auditory oddball task in ADHD compared to neurotypicals. When analyzing autonomic arousal in relation to performance on a response conflict task, among children with ADHD, those who displayed autonomic hyporeactivity to task-relevant stimuli (i.e., reduced cardiac acceleration in response to cue-stimuli) were slower to respond during the task, suggesting an indirect effect of dysregulated autonomic arousal on the relationship between ADHD and cognitive performance (Bellato et al., 2021a). Reduced vigilance and slower responses during cognitive tasks, in ADHD, may be explained by reduced activation and functioning of brain systems involved in performance monitoring and arousal regulation (such as the ACC and the anterior insula), as reported in a recent systematic review of the literature and meta-analysis (Bellato et al., 2021c).

Another group of adolescents and young adults with ADHD completed a testing battery with similar levels of complexity and engagement, including a resting-state period, a cued-continuous performance test, a flanker task, and a four-choice reaction time task (Du Rietz et al., 2019; James et al., 2020). In the baseline (slow-paced and unrewarded) condition of the reaction time task, adolescents with ADHD were found to have decreased skin conductance level than neurotypical controls, but this difference was not evident during the fast-incentive condition or during resting-state. Adamo et al. (2021) investigated whether anxiety could partly explain cognitive or physiological alterations found in this sample. Although individuals with ADHD were found to be more anxious than neurotypical controls, no association between EDA and anxiety levels were found.

Autonomic arousal in different task conditions was also measured by Robe et al. (2021), who included a resting-state baseline, a sustained attention task, and a recovery period from the attentional task, during which HR was monitored. Children and adolescents with ADHD, and young people with ADHD and co-occurring anxiety, were included in the study. Although no differences between the two groups were found on parasympathetic indices of HRV, the authors found that those with ADHD and co-occurring anxiety showed less parasympathetic activation during the task, suggesting that anxiety in ADHD may lead to reduced ability to regulate HR based on task or situational demands, compared to ADHD alone. Interestingly, both groups of children with ADHD (with or without co-occurring anxiety) did not display restoration of HRV to baseline levels after the cognitive task, suggesting that autonomic dysregulation and reduced vagal control in ADHD may also be present during the recovery from cognitive, social, or emotional stress. Unfortunately, this study did not include a control group of neurotypical children and adolescents to further validate these hypotheses, which however are worth to be investigated in future research.

To our knowledge, only one study investigating autonomic arousal in relation to reward processing has been published since the last systematic review by Bellato et al. (2020). Schloß et al. (2021) conducted a longitudinal study and followed a group of preschoolers until eight years of age. They measured reward-related autonomic reactivity (through EDA) at eight years and found reduced electrodermal reactivity in those diagnosed with ADHD compared to neurotypicals. Moreover, higher mother-reported ADHD symptoms at four/five years predicted reduced baseline EDA at eight years of age.

Socioemotional Tasks

Autonomic reactivity to emotional or social stimuli in ADHD has been investigated by several research groups. Morris and colleagues tried to replicate previous findings of reduced parasympathetic vagal control (RSA) during an emotional induction/suppression task in children with ADHD (Musser et al., 2011), by also measuring indices of sympathetic functioning (i.e., pre-ejection period (PEP) and EDA). In a recently published paper (Morris et al., 2020), the authors found that during baseline conditions (resting-state and emotionally neutral conditions), both RSA and EDA were reduced in children with ADHD compared to neurotypical controls (but PEP did not differ between the groups) and that, during the whole task, young people with ADHD displayed increased RSA reactivity (measured as the change from the neutral/baseline to the emotion-induction/suppression conditions) compared to neurotypicals. This, once again, supports the idea that both hypo and hyperarousal, in ADHD, may emerge as consequences of weaker ability to regulate autonomic arousal based on contextual demands.

Autonomic arousal has also been investigated in relation to risky behavior in ADHD. Dekkers et al. (2020), for example, involved a group of boys in different conditions of a task where risk-taking was encouraged by peers or was not encouraged (‘solo’ condition). Boys with ADHD and neurotypicals engaged more in risk taking during the ‘peer’ condition compared to the ‘solo’ condition; however, those with ADHD displayed reduced sympathetic reactivity (i.e., reduced PEP), but not different parasympathetic response (RSA), during the ‘peer’ condition. In all boys, lower sympathetic reactivity to peer influence was related to reduced behavioral susceptibility to peer influence.

Having reported delayed sympathetic responsivity and reduced parasympathetic function in response to reward in children with ADHD compared to neurotypical controls (Tenenbaum et al., 2018), Tenenbaum and colleagues investigated sympathetic and parasympathetic responsivity to emotionally salient face-stimuli during a Go/No-Go task in young people with ADHD and neurotypical controls (Tenenbaum et al., 2019). They found a different pattern of sympathetic responsivity in children with ADHD and neurotypical controls, with the former showing reductions in sympathetic activity and the latter increases in sympathetic functioning after exposure to face stimuli. Moreover, children with ADHD displayed reduced parasympathetic vagal control during the neutral condition, but no differences with neurotypical controls after exposure to the fearful face (Tenenbaum et al., 2019).

3.4.2.3 Evidence from Recent Studies on Pupil Size

Evidence of autonomic dysfunction in ADHD has also emerged from studies investigating pupil size as an index of ANS functioning. While the systematic review by Bellato et al. (2020) only identified four studies that measured pupil size in ADHD, at least eight studies have been published in the last three years alone, demonstrating a recently increased interest in focusing on pupil size as a marker of functioning of the ANS.

In adults with ADHD, larger resting-state pupil diameter was found in comparison with neurotypical controls (Nobukawa et al., 2021). The same finding (larger pupil diameter), but in relation to baseline tonic pupil size during an auditory continuous performance test, was reported by Shirama et al. (2020) in adults with ADHD together with reduced auditory stimulus-evoked phasic response of the pupil. According to the authors, these findings would suggest increased sympathetic activity in ADHD, which would be against the majority of findings emerged from investigating electrodermal or cardiovascular measures, previously reported in the chapter. However, other authors proposed that reduced parasympathetic control of the pupil, in children with ADHD, is more likely to explain larger resting-state or baseline pupil size. Hamrakova et al. (2020), for example, investigated the pupillary light reflex (pupil constrictions and dilations in response to light) and found differences between several parameters of the pupillary light reflex in children with ADHD, including reduced changes in pupil diameter during constriction, which support the idea of reduced parasympathetic regulation.

Other studies reported opposing or null findings. For example, Bast et al. (2021) investigated pupillometry in a sample of children and adolescents with ADHD, autism, or neurotypicals, during a visuospatial reaction-time task with different conditions with low and high task utility. They found no differences in tonic or phasic pupil size in response to task stimuli between those with ADHD and neurotypical controls. Interestingly, the authors found an association between larger tonic pupil size and phasic dilations, and faster reaction times, in support of theories linking autonomic arousal and task performance. Kleberg et al. (2020) found that auditory warning signals could normalize eye movements (which were slower in children with ADHD than neurotypicals) during a gap-overlap task. This improvement in task performance was accompanied by pupil dilation, a sign of increased autonomic arousal and phasic release of NE, which was found similar between children with ADHD and neurotypical controls, suggesting that both children with ADHD and controls benefited from the alerting auditory warning signals. Another study by Kleberg et al. (2021) examined pupillary responses to emotional face-stimuli in children with ADHD. Hyperactive and impulsive symptoms were associated with larger pupillary response (dilations) to happy faces (but not fearful, angry, or neutral), suggesting that exaggerated positive affect in ADHD may partly contribute to symptoms of hyperactivity and impulsivity. No associations between pupil size and inattention were reported in this study. Molina et al. (2021) investigated pupil size in relation to performance to a demanding attentional task (multiple objects tracking task) with different levels of complexity, in children with ADHD, and found that pupil size increased in relation to task complexity, but there were no differences in pupil size between children with ADHD (unmedicated and medicated) and neurotypical controls on pupil size measured during the task. Similarly, Redondo et al. (2020) measured pupil size in children with ADHD while they were performing a continuous performance test and found no differences in pupil size between children with ADHD and neurotypical controls, even though, within the ADHD group, larger pupil diameter was associated with worse task performance. Lastly, Drescher et al. (2021) conducted a pupillometry study on adults with low and high levels of ADHD traits. They manipulated the event rate (i.e., they had three different levels of pace) during a target detection task and found that phasic pupil dilation (an index of cognitive effort) was increased during the slow event rate, while tonic pupil size (an index of tonic arousal) was smallest in the fast event rate condition. Although weaker performance was found in the high ADHD group (suggesting arousal regulation difficulties), no differences in pupil measures were detected between the two groups with different levels of ADHD traits, regardless of the event rate.

3.4.3 Functioning of the Enteric Nervous System and the Gut–Brain Axis in ADHD

Functioning of the ENS in ADHD has been studied by focusing on the microbiome–gut–brain axis. It has been proposed that, in ADHD, alterations in the gut microbiota (i.e., reduced richness or diversity in the microorganisms found in the gastrointestinal tract) early in life may negatively affect functioning of the PNS (specifically, reducing vagal control), leading to emotional and behavioral dysregulation later in childhood or adolescence (Sandgren & Brummer, 2018). The role of gut microbiome in brain development and functioning is now established, as certain is its influence on neurotransmitter pathways that malfunction in ADHD (Checa-Ros et al., 2021). A recent systematic review found an association between altered composition of the gut microbiota and different conditions characterized by cognitive impairment (including ADHD, mild cognitive impairment, dementia, Alzheimer's disease, Parkinson's disease, and depression) (Barrio et al., 2022). It was specifically shown that dietary supplements used to enrich the gut microbiota (e.g., probiotics) have a positive effect on cognitive functioning, but only one study included in this review focused on ADHD.

Two systematic reviews were recently conducted by Bundgaard-Nielsen et al. (2020) and Sukmajaya et al. (2021) to investigate differences in the gut microbiota between individuals with ADHD and neurotypical controls. Bundgaard-Nielsen et al. (2020) included four studies on ADHD, while Sukmajaya et al. (2021) included six studies with heterogenous methodologies, and a clear pattern that could clarify the precise association between ADHD and altered gut microbiota did not emerge in any of these reviews. Their suggestions for future research in this rapidly evolving field is to design novel studies investigating gut microbiota function and composition, and to focus on clarifying the association between the microbiome and neurotransmitter pathways in very large samples (e.g., population studies) to allow the analysis of specific factors (including gender, weight, dietary patterns, use of medications, and other substances affecting the gut microbiota), which in previous studies could have confounded the association between altered gut microbiota and ADHD. Lastly, Payen et al. (2022) conducted a meta-analysis on the same pool of studies systematically reviewed by Sukmajaya et al. (2021), except one study (which was focused on adolescents and young adults, hence not in line with their focus on children). They found meta-analytic evidence of altered intestinal microbial diversity in children with ADHD compared to neurotypicals, e.g., significantly greater concentrations of Actinobacteria, which is again an evidence of autonomic dysregulation in ADHD.

3.4.4 Summary of Studies Investigating Autonomic Functioning in ADHD

The literature we reviewed in relation to functioning of the sympathetic, parasympathetic, and enteric branches of the ANS supports the most recent theories originated within the SRD framework and the idea that ADHD may be associated with autonomic dysfunction; more specifically, with difficulties in regulating arousal based on contextual demands.

In line with the models proposed by Aston-Jones et al. (2000, 2005, 2007, 2016) and Howells et al. (2012), there seems to be evidence that the ANS is underfunctioning in people with ADHD. For example, reduced cortisol levels (reported in the meta-analysis by Chang et al., 2021) are indicative of reduced sympathetic activity in ADHD. Similarly, underfunctioning of the ANS in ADHD is particularly evident during resting-state and more monotonous or less engaging situations (both the systematic review by Bellato et al., 2020 and more recent studies converge on this). In addition, there is also evidence that reduced parasympathetic activity in ADHD could cause difficulties in arousal regulation and hyperarousal or excessive reactivity in response to emotional and cognitive stress. This idea is supported by evidence of reduced HRV in ADHD (see the meta-analysis by Robe et al., 2019) and by more recent studies; however, this evidence is not as clear as for resting-state studies and those including less demanding experimental conditions. In line with the SRD theoretical framework, it could be speculated that people with ADHD would show a *normalized* autonomic profile (i.e., showing no differences compared to neurotypical controls) *because of* the introduction of some forms of stimulation (e.g., rewards, socioemotional stimuli, novel setting). However, the introduction of rewards and additional stimulation may also be detrimental for people with ADHD, possibly leading to arousal dysregulation in the form of hyperarousal.

Evidence from studies focusing on pupil size and the ENS are slightly less clear, probably due to the fact that researchers have only recently focused on these topics and, therefore, there is scarcity of peer-reviewed articles in the literature. Although further research is needed to confirm the relationship between functioning of the LC-NE system and pupil size, and to understand how dysfunction of the ENS is associated with ADHD, these preliminary findings seem to highlight – once again – the presence of autonomic dysregulation in ADHD and a relationship between autonomic and cognitive functioning in ADHD.

However, there are many areas which should be further clarified to better understand the possible role of autonomic dysfunction in ADHD symptomatology. These include, for example, investigating if other neurodevelopmental, psychological, and psychiatric conditions, which frequently co-occur with ADHD, are characterized by autonomic dysregulation (and, if so, how this differs from what is found in ADHD) and if pharmacological and nonpharmacological interventions for ADHD somehow affect autonomic functioning in ADHD.

3.5 Autonomic Dysregulation and Co-occurring Psychiatric Symptoms in ADHD

When trying to interpret findings of studies investigating autonomic functioning in ADHD, an important factor that should be considered is the presence of symptoms of other psychiatric and psychological conditions besides ADHD. In fact, oppositional behaviors and conduct problems, autism, mood and anxiety disorders, and tic disorders frequently co-occur with ADHD (Franke et al., 2018; Jensen & Steinhausen, 2015). In this paragraph, we will review the literature and summarize studies that investigated autonomic functioning in these conditions. As we did for ADHD, we will primarily report findings from systematic reviews and meta-analyses, and the lens will be then moved to those studies (unfortunately, only a few) that directly investigated autonomic functioning in people with ADHD and co-occurring symptoms.

3.5.1 Oppositional Defiant Disorder and Conduct Disorder

Oppositional defiant disorder (ODD) and conduct disorder (CD) are common neurodevelopmental conditions characterized by age-inappropriate or hostile, argumentative, defiant and aggressive behaviors, and emotional dysregulation (including angry or irritable mood, callousness, and lack of remorse or guilt) (American Psychiatric Association, 2013).

In a systematic review and meta-analysis, Fanti et al. (2019) investigated the association between CD and autonomic functioning (measured with HR, HRV and EDA) in children and adolescents. They included 66 studies in their meta-analyses, which showed statistically significantly reduced task-related skin conductance level (OR = −0.862, 95% CI = −1.725, −0.227) and skin conductance reactivity (OR = −0.364, 95% CI = −0.501, −0.227) in young people with conduct problems compared to neurotypical controls. Moreover, reduced task-related parasympathetic functioning (indexed by RSA) and increased sympathetic reactivity (indexed by PEP; OR = 0.597, 95% CI [0.245; 0.948]) were found in children and adolescents with conduct problems compared to neurotypicals (OR = −0.206, 95% CI = −0.398, −0.014), together with a statistically significant negative correlation between conduct problems and baseline HR (pooled correlation = −0.139, 95% CI = −0.227, −0.048) and between conduct problems and task-related HR (pooled correlation = −0.165, 95% CI = −0.265, −0.061). Although the authors did not find any between-group differences on baseline or task-related HR or HRV, baseline skin conductance activity or reactivity, these findings suggest that conduct problems may be associated with reduced activity and reactivity of the SNS, which could drive search for and engagement with risky and antisocial behaviors in people with this condition.

Several studies investigated autonomic functioning in people with ADHD and co-occurring conduct or oppositional behaviors. Crowell et al. (2006), for example, investigated cardiac measures and EDA during resting-state and a reward task in preschoolers with co-occurring ADHD and ODD, and neurotypical controls. They found that children with ADHD+ODD showed reduced resting-state SNS activity, both at rest and during the task, but no group differences were found on parasympathetic functioning. In this study, however, a group of children with ADHD without co-occurring ODD was not included, making it difficult to disentangle the separate effects of ADHD and ODD on autonomic arousal dysregulation.

When analyzing the co-occurrence of ADHD and ODD/CD in relation to autonomic functioning, some studies suggest that both conditions are similarly characterized by reduced functioning of the ANS and difficulties in arousal regulation. For example, by investigating the effects of stress on cortisol, HR, and EDA in children referred for externalizing behavior problems and neurotypical controls, Snoek et al. (2004) demonstrated a specific association between ODD and a weaker cortisol response to stress (which is also reported in ADHD, see Chang et al., 2021), while reduced EDA was found in all children with externalizing behavior problems (ADHD, ODD, and ADHD+ODD) compared to neurotypical controls. In line with these findings, Wang et al. (2013) measured resting-state HRV and disruptive behaviors in neurotypical preschoolers. They found that boys (but not girls) with higher levels of inattention, hyperactivity/impulsivity, and oppositional defiant behaviors showed reduced HRV during resting-state. Lastly, Souroulla et al. (2019) measured HR and EDA in school-aged children during resting-state and while they were watching emotionally inducing pictures from the International Affective Picture System. Parent-reported measures of ADHD and ODD traits were also obtained; their study found that lower resting-state HR and decreased EDA in response to the pictures were associated with higher ADHD traits, while both ADHD traits and ODD traits were associated with reduced cardiac reactivity in response to fear and sad stimuli.

Conversely, other studies suggest that reduced functioning of the ANS and reduced parasympathetic functioning may be specific to ADHD and not influenced by co-occurring symptoms of ODD/CD. For example, Bubier & Drabick (2008) investigated autonomic arousal and decision-making in a sample of largely impoverished children in the USA. They found that, in boys but not in girls, reduced sympathetic arousal during an emotional task predicted higher hyperactivity and impulsivity (but not ODD traits), and this was associated with problems in decision-making. Similarly, Du Rietz et al. (2019) found decreased functioning of the SNS during slow-paced conditions of a cognitive task in adolescents with ADHD (in line with the SRD model) and this was not influenced by the level of ODD traits. Lastly, van Lang et al. (2007) investigated autonomic functioning in children with ADHD with and without co-occurring ODD/CD and found that children with ADHD and co-occurring ODD/CD had slightly increased HR (compared to those with ADHD without ODD/CD) but showed similar SCL and HR reactivity and recovery.

Lastly, some studies proposed that autonomic functioning may be affected by the co-occurrence of ADHD and CD or ODD in a different way than what is found in each condition separately (i.e., children with co-occurring ADHD and ODD/CD are more likely to display autonomic dysregulation, for example, in the direction of hypoarousal, compared to those with a single diagnosis of either ADHD or ODD/CD). Bernhard et al. (2021), for example, found a greater reduction in cortisol stress response in children with ADHD and co-occurring ODD/CD, than in those with ADHD only. When investigating ODD traits in ADHD, Beauchaine et al. (2015) measured resting-state functioning of the SNS (via EDA) in preschoolers with ADHD. Children were involved, with their parents, in an intervention aimed at reducing conduct problems. The authors found that completing the intervention resulted in increased resting-state EDA, but only for children with ADHD who showed low levels of ODD traits before the intervention began. It could be speculated that those with ADHD and co-occurring high levels of ODD traits may have shown fewer positive outcomes due to more severe autonomic dysregulation before the intervention. Lastly, Delamater and Lahey (1983) investigated autonomic arousal in hyperactive children with low and high levels of conduct problems and found reduced EDA in hyperactive children with high levels of conduct problems compared to those rated low in conduct problems, in line with theories speculating an *interactive* effect of ADHD and ODD/CD on autonomic functioning.

Considering the genetic overlap (Azeredo et al., 2018) and shared symptomatology (e.g., emotional dysregulation, see Paulus et al., 2021), the literature reviewed in this paragraph seems to suggest that both ADHD and ODD/CD are characterized by autonomic dysfunction, predominantly hypoarousal and less effective arousal regulation. Moreover, the presence of co-occurring ADHD and ODD/CD may be associated with more severe autonomic dysfunction, with many potential consequences on behavior, including more severe inattention and weaker emotional regulation, which could explain the fact that a worse prognosis (e.g., in terms of social functioning, see Eskander, 2020) is likely to characterize those with co-occurring ADHD and ODD/CD. However, further research to disentangle the additive or interactive effects of these conditions on autonomic functioning is needed.

3.5.2 Autism Spectrum Disorder

Autism spectrum disorder (ASD), henceforth autism,[1] is characterized by difficulties in social interaction and communication, and repetitive/restricted behaviors (American Psychiatric Association, 2013) and has been proposed to be associated with chronic hyperarousal. Excessive autonomic functioning could explain exaggerated sensory sensitivity and stress (often evident in autistic people) and may be strategically fought by autistic people via avoiding specific sources of anxiety or stress. For example, a focus group conducted with autistic adults highlighted that restricted and repetitive behaviors are strategies adopted by autistic people to self-regulate in overwhelming environments characterized by sensory overload and internally generated thoughts that cause uncontainable emotions (e.g., anxiety) (Kapp et al., 2019). Within the context of autonomic arousal, it could be speculated that restricted and repetitive behaviors in autism are attempts to reduce hyperarousal by limiting sensory input and making the environment more predictable. However, behavioral signs of hypoarousal (e.g., inattention and reduced vigilance) are also often observed in autistic people,

[1] Aware of the debate on the use of 'person-first' or 'identity-first' language to refer to people who received a diagnosis of autism spectrum disorder, we decided to use 'autistic people' since this is what the majority of a sample of autistic adults, family members or friends and parents of an autistic person have reported to prefer in an online survey conducted in the United Kingdom (Kenny et al., 2015). We are also aware though that this may not be the case for other countries.

as in ADHD. As suggested by Arora et al. (2021), these two perspectives are likely to not be mutually exclusive, and the literature we will present in this paragraph supports this idea. Specifically, there seem to be subgroups of autistic people characterized by different autonomic profiles, highlighting the importance of investigating autonomic dysfunction in relation to transdiagnostic clusters of psychopathological symptoms.

Some authors (see Condy et al., 2019, for a systematic review) proposed that restricted repetitive behaviors in autism, reflecting cognitive–behavioral inflexibility, could arise from altered functioning of the central autonomic network. Specifically, less effective parasympathetic control over HR (reflected in reduced HRV) in response to stress may cause increased anxiety and difficulties in downregulating autonomic arousal in autistic people. Cheng et al. (2020) conducted a systematic review and meta-analysis to confirm this hypothesis and included 34 studies investigating differences in HRV between autistic and nonautistic people. The meta-analysis on baseline HRV (962 autistic people vs 977 nonautistic controls) was statistically significant (Hedge's $= -0.5169$; 95% CI $= -0.7479, -0.2859$), as was the meta-analysis on HRV reactivity (361 autistic people vs 460 nonautistic controls; Hedge's $= -0.4647$; 95% CI $= -0.7742; -0.1552$). Based on these findings, it can be concluded that autistic people are likely to display reduced baseline HRV and HRV reactivity (especially in situations of social stress and social debriefing). The largest effects were found for RSA reactivity, suggesting that cardiac vagal control may be reduced in many situations, in autistic people, but especially in relation to exposure to social stress.

Arora et al. (2021) systematically reviewed the literature on resting-state functioning of the ANS in autism, by including different indices (e.g., HR/HRV, EDA, and pupil). Sixty studies were included in this systematic review, 60% of which found evidence of dysregulated functioning of the ANS in autism. While findings of hyperarousal were more common, especially in relation to indices of parasympathetic function (as reported in Condy et al., 2019 and Cheng et al., 2020), evidence of reduced functioning of the ANS in autism was also found. The authors suggested that experimental context was likely to play a role in revealing such differences, as reported for ADHD (Bellato et al., 2020). Lydon et al. (2016) conducted a systematic review of the literature to investigate whether autonomic reactivity (measured through EDA, HR, HRV, cortisol, and blood pressure), in autistic people, was influenced by the specific nature of the stimulus or object in relation to which autonomic reactivity was measured. The authors reported that autistic people are likely to show altered reactivity to several stimuli, including sensory, social and emotional, and stressor stimuli, compared to nonautistic people. Although findings mostly supported the idea of increased physiological reactivity in autism, they were not uniform and suggested the fact that hyperarousal and increased autonomic reactivity may only characterize a subgroup of autistic people. Further research is needed to identify what factors are associated with autonomic dysregulation in autism, or – to be more precise – at least in a subgroup of people within this population.

Pupillometry studies in autism have been systematically and meta-analytically investigated by de Vries et al. (2021), who found that autistic people show longer latencies of the pupil response compared to nonautistic people (Hedge's $g = 1.03$; 95% CI $= 0.49, 1.56$), but not different baseline pupil size or pupil reactivity. Considering the difficulty in interpreting pupillometry findings, as for ADHD, future studies are encouraged to investigate changes in indices of autonomic functioning (including pupil size and pupil reactivity) in relation to different sensory stimuli, in autistic people.

Lastly, it has been proposed that alterations in the gut–microbiota may be associated with autistic symptomatology and could originate from dysfunction of the ANS. Specifically, excessive activity of the SNS in autism, due to reduced parasympathetic control, could lead to altered functioning of the gut–brain axis, negatively affecting the functioning of the ENS and the gastrointestinal system, leading to neuroinflammation (Beopoulos et al., 2021).

This idea has been corroborated by a systematic review by Bundgaard-Nielsen et al. (2020): in this work, most of the included studies found different microbiota composition in autistic people compared to neurotypical controls.

Different theoretical models have tried to predict the influence of co-occurring ADHD and autism on autonomic arousal, but only a reduced number of studies have directly investigated autonomic arousal in people with ADHD and co-occurring autism. In their study (already presented in relation to ADHD), Bellato et al. (2021b) recruited autistic children and children with a double diagnosis of ADHD and autism. They found signs of hyperarousal in autistic children, during a passive auditory attention task and during an active response conflict task (but not during resting-state), mainly associated with reduced parasympathetic functioning. Children with a double diagnosis of ADHD and autism did not display a unique profile distinct from the autism- and the ADHD-only groups, but they showed the same alterations reported in children with 'pure' conditions, i.e., reduced sympathetic functioning during resting-state and a passive auditory attentional task (like the ADHD-only group) and reduced parasympathetic activation during the cognitively challenging response conflict task (like the autism-only group). These findings, at least in the domain of arousal dysregulation, support the *additive* theoretical model of co-occurrence between ADHD and autism, which proposes that these neurodevelopmental conditions might emerge together from shared or similar risk factors, but their phenotypical expression in the same individual would be an additive combination of each condition's specific characteristics (Craig et al., 2016; Leitner, 2014; Tye et al., 2014). To note, this contrasts with the evidence presented above in relation to the co-occurrence between ADHD and ODD/CD.

When analyzing the whole sample of children with a single diagnosis of ADHD and autism, and those with a double diagnosis of ADHD + autism, by adopting a transdiagnostic approach, Bellato, Arora, and colleagues found that children showing indices of hyperarousal displayed more severe parent-reported difficulties in social interactions and communication, greater anxiety, and reduced global functioning (Bellato et al., 2021b). Another study that investigated autonomic functioning in children with ADHD and co-occurring autism was conducted by Boxhoorn et al. (2020). They investigated pupil dilations during a cued visuospatial orienting task and found that autistic children (irrespectively of a co-occurring diagnosis of ADHD) displayed larger pupil dilations (reflecting increased autonomic reactivity) in response to task-relevant stimuli compared to neurotypical children and those with ADHD-only.

In summary, the findings presented in this paragraph seem to converge toward the evidence of the presence of at least a subgroup of autistic people characterized by hyperarousal and autonomic hyperreactivity to stimuli of different nature, probably due to reduced or less effective parasympathetic regulation. When autism co-occurs with ADHD, autonomic alterations that usually separately characterize these conditions (e.g., hypoarousal during more monotonous or less engaging situations, and hyperarousal during cognitively or emotionally challenging situations) may appear concurrently and may be associated with more severe difficulties in emotion regulation and negative consequences on cognitive performance and behavior.

3.5.3 Mood Disorder and Emotional Dysregulation

Emotional symptoms and mood dysregulation are often reported in people with ADHD and include emotional impulsivity or dysregulation, anxiety, and depression (Faraone et al., 2021). There is some evidence that mood dysregulation is associated with altered autonomic functioning (Bellato et al., 2023). Specifically, systematic reviews and meta-analyses have reported reduced EDA in people with depression (Sarchiapone et al., 2018) and reduced HRV in people with both anxiety and depression (Alvares et al., 2016). Moreover, the existing literature suggests that increased emotional dysregulation (i.e., the presence of emotional responses and experiences that interfere with behavior) in people with different conditions, including ADHD, may be associated with reduced parasympathetically mediated vagal control.

Shaw et al. (2014), in a review of the literature on emotional dysregulation in ADHD, concluded that emotional dysregulation is highly prevalent in this condition and is associated with different aspects of ADHD symptomatology. This has also been confirmed by studies reporting reduced electrophysiological correlates of emotional regulation in ADHD (see, for example, Van Cauwenberge et al., 2017). Several studies have investigated the association between emotion regulation difficulties and autonomic functioning in ADHD. For example, Bunford et al. (2017) showed that better emotion regulation is associated with increased HRV in children with ADHD. Musser and colleagues carried out different studies on this topic using an emotion-inducing and emotion-suppression task. In 2011, they reported that children with ADHD showed less variability in RSA, an index of parasympathetic functioning, which was however found to be elevated throughout the task, signaling altered parasympathetic regulation in relation to emotion regulation in ADHD, but no alterations in sympathetic functioning (PEP) compared to neurotypical controls (Musser et al., 2011). In another study (2013), they found that children with ADHD showing age-appropriate prosocial behaviors displayed increased parasympathetic reactivity while watching positive emotional-inducing videos and increased sympathetic activity throughout the task; while those with ADHD and low prosocial behavior (i.e., high in callous/unemotional traits) displayed reduced parasympathetic reactivity and reduced sympathetic activity. Using the same task but investigating the association between HRV and facial affect, they found no differences between children with ADHD and neurotypical controls on the rates of facial affect behavior displayed, but the ADHD group showed reduced coherence between facial affect behavior and RSA, an index of parasympathetic functioning, while neurotypical peers showed a significant, positive association between facial affect behavior and RSA (Musser & Nigg, 2019).

McQuade and Breaux (2017) investigated autonomic arousal (using HR and EDA) in relation to executive functioning and emotional regulation during experiences of failure and social stress, in children with different levels of ADHD traits. ADHD traits were found associated with emotional dysregulation during childhood and with reduced parasympathetic activation in response to an experience of social rejection (McQuade & Breaux, 2017). When followed up a few years later, adolescents with low electrodermal reactivity in response to social stress showed lowest borderline personality traits, but only if they had supportive parents (McQuade et al., 2022). Considering that ADHD traits measured during childhood significantly positively correlated with borderline personality traits measured in adolescence, these findings suggest a potentially protective influence of parental support on the relationships between ADHD, weaker arousal regulation, and psychopathology.

Taskiran et al. (2018) investigated cardiac reactivity in school-aged children with ADHD, with and without emotion dysregulation, and neurotypical controls, in response to emotionally evocative visual stimuli. They found that the groups differed only on cardiac reactivity (measured as the difference in HR between baseline measurement and measurement taken after exposure to the visual stimuli) in response to unpleasant stimuli. Specifically, children with ADHD and emotional dysregulation showed lower cardiac reactivity in response to unpleasant stimuli but rated these as more negative, compared to children with ADHD without emotional dysregulation, and compared to neurotypical controls. Moreover, higher temperamental negative reactivity, lower prosocial behaviors, and more oppositional/conduct problems were found in the group of children with ADHD and emotional dysregulation. Lastly, Beauchaine et al. (2013) investigated autonomic arousal at baseline, during a reward task and a block-building task in preschoolers with ADHD. They found that children who exhibited increased emotional dysregulation had reduced parasympathetic functioning at baseline and during the block-building task.

Some other studies directly compared children with ADHD and those with a Mood Disorder (e.g., anxiety) on measures of autonomic arousal. For example, van Lang et al. (2007) investigated activity of the ANS in children with ADHD or with anxiety disorder during a stress task. They found that, compared to the group of children with anxiety disorder, the group of children with ADHD was similar in relation to EDA but showed reduced HR reactivity after the stress task, suggesting reduced functioning of the ANS in the ADHD group and increased reactivity to stress in those with anxiety. Other studies investigated anxiety as a co-occurring set of symptoms in ADHD. In a sample of children and adolescents with ADHD and neurotypical controls, Griffiths et al. (2017) measured HRV during resting-state and a sustained attention task and found that reduced HRV was associated with higher anxiety in the whole sample. Similarly, Bellato et al. (2021b), for which we have already presented the main findings in relation to ADHD and autism, found that reduced parasympathetic functioning (measured across a testing battery that included resting state, a passive auditory attention task, and a response conflict task) was associated with increased anxiety in children with ADHD, autism, and co-occurring ADHD + autism.

This is likely to suggest that when mood dysregulation is present in addition to ADHD, autonomic functioning may be further affected, with potentially even more negative outcomes on well-being and quality of life. Some studies have tested this hypothesis. For example, Robe et al. (2021) (whose study we have already presented in relation to ADHD) measured HR during a resting-state baseline, a sustained attention task, and a recovery period in young people with ADHD, with or without co-occurring anxiety. Although they did not find any group differences on HRV during the different tasks, they found that co-occurring anxiety in ADHD was associated with reduced modulation of parasympathetic activity from baseline to task to recovery, suggesting that the co-occurrence of anxiety and ADHD may indeed be associated with more severe autonomic dysregulation than *pure* ADHD.

Overall, these findings seem to indicate that emotional dysregulation and mood fluctuations may arise from less effective parasympathetic control and autonomic hyperreactivity to emotional stress, and this association may not be specific for ADHD, in line with the theoretical models that proposed emotional and autonomic dysregulation to be transdiagnostic markers of psychopathology (Beauchaine & Thayer, 2015).

3.5.4 Sluggish-Cognitive Tempo

Sluggish-cognitive tempo (SCT) refers to a set of behavioral symptoms that include fluctuations in alertness and vigilance, drowsiness, and sluggish responsiveness, which partly overlap with ADHD symptomatology and are associated with behavioral inhibition and internalizing symptoms. It has been proposed that SCT behaviors may derive from reduced functioning of the ANS (which, as we have discussed in the previous paragraphs, is evident in people with ADHD, at least in some situations). However, although SCT behaviors may be present in some people with ADHD, they have been proposed to be a separate dimension of psychopathology that can be found across several conditions (Becker & Willcutt, 2019).

Some studies investigated autonomic arousal in relation to SCT behaviors and ADHD traits. Yung et al. (2020) investigated the relationship between HRV (measured during resting-state and a warning signal paradigm), SCT, and ADHD traits, and found that SCT traits were positively associated with lower sympathetic activity, when controlling for ADHD traits, in school-aged children. Becker and McQuade (2020) measured parasympathetic and sympathetic functioning (via RSA and EDA, respectively) in relation to SCT behaviors in children with different levels of clinical and subclinical traits of ADHD, and in neurotypicals, during a peer rejection task and an impossible puzzle task. Across the whole sample, higher SCT symptoms were associated with increased electrodermal reactivity to peer rejection, but not with RSA.

Although there are only a few studies investigating SCT behaviors in ADHD, the patterns of autonomic functioning associated with SCT seem to resemble what we observed in ADHD; although they may be separate entities (at least from a clinical perspective), reduced functioning of the ANS and difficulties in arousal regulation may characterize both conditions, and this could explain the overlapping symptomatology, especially in relation to inattention, drowsiness, and sluggish responsiveness.

3.6 Effects of Pharmacological and Nonpharmacological Interventions for ADHD on Autonomic Nervous System Functioning

Evidence-based first-choice interventions for ADHD include pharmacological interventions with stimulants (such as methylphenidate and amphetamines) or nonstimulants (including atomoxetine and guanfacine) in combination with behavior therapy, with methylphenidate being the first choice for short-term improvement of ADHD symptoms in children, and amphetamines being preferred in adults (Cortese et al., 2018). Considering that medications for ADHD influence the same noradrenergic and dopaminergic pathways that are likely to be involved in autonomic arousal, it could be speculated that ADHD medications have some influence on the ANS. Animal studies (see, for example, Kharas et al., 2017) showed that methylphenidate increases neuronal activity in the LC and promotes phasic release of NE, and this is accompanied by reduced behavioral hyperactivity (Devilbiss & Berridge, 2006). Other studies, in children with ADHD (see, for example, van der Meere et al., 2009), found that methylphenidate may be specifically beneficial for performance in slow-paced conditions (i.e., methylphenidate produces more accurate and faster performance) but may have a negative impact during fast conditions (probably due to the combined stimulating effect of a fast-paced task and methylphenidate), resulting in a faster but more inaccurate response style.

Almost every study that investigated the effects of medication on primary symptoms of ADHD in humans reported data on HR and blood pressure. In most cases, however, this has been done to identify side effects and not to directly measure the effects of ADHD medication on ANS functioning. In fact, only a few studies have specifically investigated if and how changes in peripheral indices of autonomic arousal, such as EDA, pupil size, or HRV, are associated with medication use in ADHD. It is therefore not clear if improvements in inattention and hyperactivity, due to medication, are also accompanied by changes in autonomic functioning in people with ADHD. If this would be the case, it could be speculated that medications ameliorate ADHD symptoms by *normalizing* activity of the ANS (as proposed by Rash & Aguirre-Camacho, 2012). In those people for whom drugs (especially stimulants) cause autonomic-related side effects such as cardiovascular problems (e.g., increased HR and blood pressure; Liang et al., 2018), difficulties in sleeping (Storebo et al., 2015), and other unpleasant somatic effects, it could be that medication exerts an exaggerated influence on autonomic functioning and causes hyperactivity of the ANS; the validity of this idea, however, still has to be tested.

In their systematic review of the literature, Bellato et al. (2020) analyzed a subgroup of studies reporting on the effects of methylphenidate on indices of ANS functioning. Most of these studies found signs of autonomic *normalization*, which accompanied improvements in performance on cognitive, social, and attentional tasks. In most of these studies, signs of hypoarousal (e.g., reduced EDA) were evident in unmedicated people with ADHD but disappeared when they were under medication (hence, no differences were found between those with and without ADHD). Similar findings were reported in a systematic review recently published (Idrees et al., 2023). Morris et al. (2021) investigated the effects of methylphenidate on sympathetic and parasympathetic functioning in children with ADHD and neurotypical controls, and found that those with ADHD showed reduced resting-state EDA and RSA compared to neurotypical peers in the placebo condition (i.e., when unmedicated). However, when they were medicated, signs of reduced functioning of the ANS were not detected in those with ADHD, who showed similar EDA and RSA than controls. In relation to the effects of medication on other indices of ANS functioning, there is not much literature, apart from Redondo et al. (2020) who did not find any effect of methylphenidate on pupil size. All these findings, considered together with the vast literature reporting stimulant-related increase in HR and blood pressure (see, for example, Liang et al., 2018; and Hennissen et al., 2017), seem to suggest that stimulant medication for ADHD is likely to exert an excitatory effect on the ANS, *normalizing* levels of autonomic hypoarousal in people with ADHD.

Unlike stimulants, nonstimulants such as clonidine and guanfacine tend to reduce HR and blood pressure (Sayer et al., 2016), and this may indicate that they may have a different influence on the ANS. Considering that, to our knowledge, no study has investigated the effects of this type of medication for ADHD on ANS functioning, and we acknowledge the need to address this gap in the literature. Moreover, the mechanisms underlying the concurrent effects of stimulant medication on both ADHD symptoms and autonomic functioning should be further investigated, to clarify the potential utility of monitoring the effectiveness of different types of medication for ADHD via indices of autonomic functioning.

Autonomic functioning in ADHD has been found to be influenced by nonpharmacological interventions or other external factors. For example, Eisenberg et al. (2004) found positive effects of HRV-based biofeedback intervention on parent-reported ADHD symptoms and psychological well-being in children with ADHD. Similarly, Groeneveld et al. (2019) reported positive effects of combined EEG-neurofeedback and HRV-based biofeedback on ADHD symptoms and attentional control for both children and adults with ADHD. This was paralleled by an increase in HRV after the intervention, compared to before. Similarly, Nada (2009) found that HRV-biofeedback was effective in increasing HRV in a small sample of children with different conditions, but this was predominantly evident in children with conduct and anxiety disorders and less evident in those with ADHD. O'Connell et al. (2008) found that a biofeedback training based on EDA was associated with postintervention increases in EDA, better arousal regulation, and improved sustained attention in a sample of young adults with ADHD. Lastly, Johnstone et al. (2010) found that EDA increased after a computer-based working memory and response inhibition training in children with ADHD, who also showed reduced severity of primary symptoms and improved performance on a Go/No-Go task after the intervention.

In relation to external factors that potentially influence autonomic activity, Madjar et al. (2020) found that listening to music improved reading performance in children and adolescents with ADHD (but not in neurotypical controls), and this was explained by changes in HRV, so that only those who showed less variable but increased HRV while listening to music demonstrated an improvement in reading comprehension. Yu et al. (2020) found no effects of aerobic exercise on resting-state HRV in children with ADHD but found exercise-related improvements on inhibitory control and greater amplitude of electrophysiological indices of response inhibition. Conversely, Ludyga et al. (2020) reported increased cognitive flexibility following aerobic exercise and increased autonomic arousal due to parasympathetic withdrawal both in children with ADHD and neurotypical controls.

To sum up, the literature presented in this paragraph seems to point toward the idea that autonomic dysfunction in ADHD could be ameliorated by medication, and this may underlie changes in behavior and improvements in global, social, and cognitive functioning in people with ADHD treated with stimulants or nonstimulants. Importantly, there is also evidence that nonpharmacological interventions may exert similar effects on ANS functioning, highlighting the importance of studying the influence of other forms of stimulation on autonomic functioning in ADHD. In the short-term future, it would be important to understand if markers of autonomic functioning (e.g., HRV, EDA, or pupil reactivity) can be used to predict, when measured at baseline, the effectiveness of a certain intervention (pharmacological or nonpharmacological) and if, when measured during the course of an intervention, they can be used to remotely monitor the effects of such intervention and/or support the clinician in making decisions accordingly (e.g., in relation to modifying the treatment regimens or deciding to stop the treatment).

3.7 Implications and Future Directions

The aim of this chapter is to provide a comprehensive overview of the autonomic nervous system and its role in ADHD pathophysiology and symptomatology. We would like to now discuss the implications of the literature we covered in the previous sections and present important questions that should be addressed by future research.

3.7.1 Theoretical Models of ADHD

Among the several theoretical models attempting to clarify the mechanisms underlying behavioral, cognitive, and emotional difficulties associated with ADHD, the literature we reviewed in relation to functioning of the sympathetic, parasympathetic, and enteric branches of the ANS in ADHD predominantly supports the SRD and the neurovisceral integration models. The main idea supported by evidence is that ADHD is associated with autonomic dysfunction, more specifically, with difficulties in regulating arousal based on contextual demands. These difficulties may already be evident before the symptoms of ADHD appear. Altered functioning of central and peripheral autonomic systems from early in life (e.g., due to environmental stressors), in fact, may lead to atypical structural and functional development of brain systems responsible for self-regulating behaviors (as speculated in the vertical-integrative model by Geva & Feldman, 2008; Geva et al., 2017). In line with the SRD framework, situations characterized by appropriate sensory stimulation, pace, and emotional balance may support the achievement of optimal arousal in both neurotypicals and people with ADHD. However, reduced activity of the ANS during situations characterized by low sensory stimulation or slow pace may specifically trigger drowsiness and inattention in those with ADHD. While additional effort allocation may be sufficient for neurotypicals to achieve optimal arousal and support behavior during such situations, in people with ADHD hyperactivity, restlessness and fidgeting may be strategic attempts implemented to upregulate arousal. Although we are not aware of any studies investigating the functional nature of hyperactivity as an autonomic arousal regulation strategy in ADHD, it has been shown that fidgeting in neurotypical adults is preceded by transient inattentiveness and spontaneous mind wandering (Carriere et al., 2013), suggesting a potentially functional role of motor hyperactivity for arousal regulation.

Moreover, it has also been proposed that exploratory behaviors that accompany boredom have an upregulating effect on autonomic arousal in humans (Bench & Lench, 2013), and this may be true for ADHD as well. For example, Börger & van der Meere (2000) investigated the visual behavior of children with ADHD during two continuous performance tests, one with a regular stimulus presentation rate and one with an irregular rate. They found that children with ADHD looked away from the screen during the interval between the presentation of successive stimuli, and this was interpreted as a compensatory strategy to upregulate arousal, which was effective during the regularly paced task but was detrimental when the interval between appearance of successive visual stimuli was irregular. Lastly, weaker parasympathetic control (e.g., due to reduced functioning of brain systems involved in self-regulation, such as the ACC, the vmPFC, or the OFC), in people with ADHD, may cause difficulties in downregulating arousal, which, consequently, may lead to hyperarousal in response to emotional stress. Although these ideas are supported by previous literature, the autonomic mechanisms underlying hypoarousal and emotional dysregulation in ADHD are not yet fully defined; therefore, further research is needed.

While there is ample evidence of arousal dysregulation in ADHD, in fact, we still do not know what the causes of autonomic dysfunction and arousal regulation difficulties in ADHD are.

For example, it has been proposed that the LC may function atypically in ADHD; however, no study has been published yet, investigating LC functioning (e.g., via fMRI) in people with ADHD compared to neurotypicals. Moreover, although brain hypoarousal in ADHD has been reported by many studies that used EEG or fMRI, only a few studies investigated changes in brain activity in response to extreme levels of stimulation, e.g., very slow- vs very fast-paced cognitive tasks, in people with ADHD (Buyck & Wiersema, 2015). There is, however, preliminary evidence of atypically increased activation of the Default-Mode Network in ADHD during slow and fast event rates, but not during moderate event rate (Metin et al., 2015), suggesting that alterations in brain functioning in ADHD may be predominantly evident during nonoptimal arousal states requiring additional effort allocation.

Related to this, it would be important for future research to clarify if atypical functioning of the LC, or atypical regulation of the LC by prefrontal areas (including the ACC, OFC, and vmPFC), or both, are associated with arousal dysregulation in ADHD. The evidence presented in this chapter seems to point toward the latter hypothesis; both hypoactivation of the SNS (specifically, reduced functioning of the LC) and weaker regulation of the LC by prefrontal structures (hence, reduced parasympathetic control) are likely to characterize ADHD. Effective autonomic arousal regulation in suboptimal conditions also requires awareness and monitoring of bodily state, and literature on this topic is scarce and findings are inconclusive. For example, Wiersema & Godefroid (2018) did not find any differences in interoceptive awareness (measured via a heartbeat detection task and self-reported) between adults with ADHD and neurotypical controls, while Kutscheidt et al. (2019) found that adults with ADHD display less awareness of internal bodily signals, i.e., heartbeats.

Besides highlighting an association between autonomic dysfunction and core features of ADHD pathophysiology, the literature reviewed in this chapter suggests that autonomic dysfunction and deficient arousal regulation are likely to be associated with symptomatologic domains that cross diagnostic boundaries and not only pertain to ADHD, such as emotional dysregulation. An important aim for future research would therefore be working toward disentangling the specific associations between certain patterns of autonomic dysfunction and both condition-specific and transdiagnostic symptomatologic domains. Future research could investigate, for example, the association between domains of human functioning (including autonomic arousal and arousal regulation), clinical and behavioral symptoms of neurodevelopmental and psychiatric conditions, in line with the Research Domain Criteria framework (RDoC; Cuthbert & Insel, 2013) and the Hierarchical Taxonomy of Psychopathology system (HiTOP; Kotov et al., 2017).

3.7.2 Implications for Clinical Practice

Accurately measuring autonomic arousal in people with ADHD (e.g., by using wearable devices such as smartwatches) is likely to have positive implications on many areas of clinical practice. Based on the literature we presented in the chapter, we stand against using measures of autonomic arousal as diagnostic and clinical biomarkers of ADHD, since autonomic dysfunction seems not specific enough to this condition. Considering the heterogeneity in clinical presentation (both in relation to primary characteristics of ADHD and co-occurring symptoms), it would probably be more important for clinicians to understand in what situations their patients struggle the most in terms of self-regulation and reduced behavioral control, and what strategies they naturally adopt to achieve optimal arousal in those situations.

Hence, it is crucial that standardized instruments that accurately and reliably assess autonomic functioning and dysfunction are developed. Being able to obtain objective measures of activity in each branch of the ANS (sympathetic, parasympathetic, enteric) and to recognize autonomic dysfunction based on normative data (controlling, for example, for age and sex) would be helpful for clinicians to track and monitor autonomic functioning over time, both in people with ADHD and those with other neurodevelopmental or psychiatric conditions. For instance, combining self-reports and continuous measurement of autonomic activity (e.g., HRV) may be a reliable method for evaluating whether adopting specific cognitive–behavioral strategies that promote arousal regulation (e.g., slow-breathing and mindfulness) works for a certain person and in which situations. This would be similar to cardiovascular measures and clinical symptoms (based on parent- or teacher report) being used by clinicians to track the effects of certain medications for ADHD. Another advantage of using wristbands and smartwatches that record HR and HRV would be the possibility to remotely track autonomic activity, without requiring the person with ADHD to visit the clinic for follow-ups.

Dedicating time and financial resources to study the effects of existing interventions for ADHD on autonomic functioning is likely to clarify why some are more effective than others in reducing the severity of symptoms. For example, prescribing stimulants to a person with ADHD without knowing that they display signs of hyperfunctioning of the ANS (e.g., due to co-occurring autism) may lead to the onset of autonomic and somatic unpleasant side effects, potentially avoidable by investigating the person's autonomic profile before choosing among the treatment options. If changes in autonomic arousal are indeed found to mediate the association between medication use and improvements in behavioral and clinical symptoms (as we speculated earlier in the chapter), these measures could be used to remotely monitor the ongoing treatment and anticipate the onset of side effects. This could be particularly helpful for people living in remote or rural areas, or in low-resource settings with scarcity of healthcare professionals. Therefore, an important gap that future research should try to fill is understanding the precise effects of different types of ADHD medication (i.e., stimulants and nonstimulants) on indices of autonomic arousal and ANS functioning (including but not limited to HR, HRV, EDA, and pupil size). This investigation should be prioritized, considering that it is likely to lead to important advancements in our understanding of the mechanisms underlying the effectiveness of pharmacological interventions for ADHD.

Having said that, we acknowledge that not every person with ADHD is equally likely to benefit from pharmacological or nonpharmacological interventions (e.g., exercise interventions, mindfulness, or biofeedback) aimed at normalizing activity in the ANS and improving arousal regulation, mainly due to heterogeneity in clinical profiles. Some may show signs of normalization in controlled situations (e.g., in the lab or in the clinic) but not in everyday life; others may not show any improvements at all, or they may display negative effects. Besides asking people with ADHD to commit and be actively involved in attempting to change their behavior to promote better arousal regulation, society should work toward identifying what environmental adaptations and modifications are more likely to meet the needs of people with ADHD and how they can be best supported. These strategies include, for example, using engaging stimuli, positive rewards and reinforcers, and self-paced tasks, for children involved in cognitively challenging activities at school or in the workplace, allowing longer breaks for adults with ADHD to have enough time to rebalance their level of arousal and activation before starting their work again. A good practice, when working with people with ADHD, would therefore be to propose personalized interventions and involve members of their social and occupational circles (e.g., teachers, relatives, and employers) in such interventions. The primary goal of our clinical practice – which we shall never forget – is promoting the well-being and improving the quality of life of people we are working with.

3.7.3 Open Questions for Future Research

As demonstrated throughout this chapter, measuring activity and functioning of the ANS in different situations (both experimental and naturalistic) is likely to lead to a better understanding of the relationships between autonomic arousal and behavior in people with ADHD. However, the small size and deep location of the LC make it hard to measure neuronal activity in this brainstem structure, which is thought to be primarily involved in autonomic arousal. Concurrently investigating different autonomic measures, such as HR, EDA, and pupillometry, and using neuroimaging (e.g., EEG or fMRI) or behavioral measures collected in different conditions (e.g., resting-state, passive tasks, and active tasks with different levels of engagement and difficulty) might prove helpful to clarify the precise involvement of central and peripheral autonomic systems in arousal and arousal regulation, and, more generally, in cognition, behavior, and social functioning. However, it should also be acknowledged that some peripheral measures of autonomic functioning may be sensitive to certain characteristics of the external environment. For example, the pupil is affected by luminance (not only of the surroundings but also of visual stimuli presented on a computer screen), while temperature and humidity are likely to affect EDA measurement. Lastly, it shall also be acknowledged that, for children with ADHD, being in a new environment or carrying out an activity they never tried before may be stimulating or arousing and could elicit exploratory behaviors, naturally promoting engagement. Hence, it would be important to consider all these potentially confounding factors when designing research studies aimed at investigating autonomic arousal in people with ADHD.

It would be interesting to test, if hyperactive behaviors and motor activity play a role in arousal regulation in people with ADHD, and to investigate the effects, on autonomic functioning, of deliberate control and suppression of motor behaviors. There is, in fact, preliminary evidence indicating that motor activity is functional in people with ADHD and may act as a compensatory mechanism to reach and maintain optimal arousal. (Börger & van der Meere, 2000; Sonuga-Barke et al., 2010). Sarver et al. (2015), for example, showed that children with ADHD who displayed increased levels of activity performed better (but not yet at neurotypical level) in a series of working memory tasks, while neurotypical children performed slightly worse when they exhibited increased motor activity (Sarver et al., 2015). Furthermore, in a meta-analysis of 63 studies, Kofler et al. (2016) found that increased motor activity characterized children with ADHD compared to neurotypicals, especially during situations characterized by high cognitive demand. Although these findings suggest that hyperactivity may be functional and helpful (at least in some situations) or necessary to regulate arousal to improve cognitive performance in people with ADHD, more research is needed to clarify the specific effects of motor activity on autonomic and brain arousal (both in neurotypicals and people with ADHD).

Similarly, it would be important to understand if subgroups of children presenting with different symptomatologic profiles (e.g., inattentive, hyperactive, and combined) display different patterns of autonomic functioning. Moreover, considering the literature reviewed in relation to psychiatric and neurodevelopmental conditions that often co-occur with ADHD, adopting a dimensional approach to the study of autonomic arousal in large groups of people presenting heterogeneous symptomatologic profiles (in line with the RDoC and the HiTOP frameworks) could help to identify specific associations between clusters of symptoms and autonomic dysregulation. For example, it would be important to identify if autonomic dysregulation is transdiagnostically associated with anxiety, increased risk of self-harm and suicide, aggression, and reduced global or social functioning. Lastly, we suggest that future research should investigate what are the early signs, if any, of autonomic dysregulation in infants at risk of developing ADHD (e.g., born preterm, siblings of children with a clinical diagnosis, or from disadvantaged socioeconomic background), and if appropriate interventions, started early in life, could improve self-regulation and minimize the negative outcomes associated with ADHD.

3.8 Conclusions

We would like to conclude the chapter with a summary of the key take-home messages that emerged from reviewing the existing evidence about the role of the autonomic nervous system in ADHD. This is an evolving area of research that has recently become again central in the study of ADHD and other neurodevelopmental or psychiatric conditions, and which we think will keep a central spot in the short-term future.

– Medical conditions and physical symptoms diagnosed or self-reported in people with ADHD suggest autonomic dysregulation or altered functioning of the ANS in this condition.
– Lower levels of cortisol and alpha-amylase in people with ADHD suggest reduced sympathetic activity.
– Reduced sympathetic functioning in ADHD seems to be predominantly evident during resting state or in situations that are more monotonous and less engaging.
– Although findings are mixed, reduced sympathetic reactivity and parasympathetic control have been found in response to cognitive and emotional stress in people with ADHD.
– Altered functioning of the enteric branch is evident in people with ADHD.
– Autonomic dysfunction is also evident in people with nonclinical but elevated traits of ADHD.
– People with ODD or CD seem to present an autonomic profile that is similar to what is found in people with ADHD. The co-occurring presence of ADHD and ODD/CD is likely to increase the severity of autonomic dysregulation with important consequences for global, social, and cognitive functioning.
– At least a subgroup of autistic people may present with an opposite autonomic profile than ADHD, characterized by hyperarousal, increased stress, and sensory hypersensitivity, predominantly during cognitive and socioemotional tasks. People with a double diagnosis of ADHD and autism may present with an additive profile of autonomic symptoms separately reported in the two conditions.
– Reduced parasympathetic regulation and consequent hyperreactivity to emotional stress are associated with increased emotional dysregulation and emotional symptoms in ADHD (but also in other neurodevelopmental and psychiatric conditions).
– SCT behaviors could be partly explained by reduced functioning of the ANS and weaker arousal regulation, as in ADHD.
– Autonomic dysfunction in ADHD could be improved by pharmacological interventions, and this may explain the beneficial effects of stimulant and nonstimulant medications on behavior, and global, social, and cognitive functioning.
– Future research is needed and should aim to:
  (a) Develop an evidence-driven theory of ADHD that will integrate previous theoretical frameworks.
  (b) Clarify if autonomic dysregulation, early in life, is associated with the onset of specific behavioral symptoms during the childhood and adolescence (e.g., inattention, conduct problems, and emotional dysregulation).
  (c) Determine the effects of pharmacological and nonpharmacological interventions (and environmental modifications) on autonomic arousal in people with ADHD and verify the potential utility of markers of ANS functioning to predict the treatment response.

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Effects of Alertness and Inhibitory Control on Adults with ADHD

4

Keitaro Machida and Katherine A. Johnson

4.1 Introduction

The ability to be awake, alert, and ready to act along with the ability to decide when to act and when to withhold an action are two fundamental cognitive tasks that are essential for everyday life and survival. Difficulties with alerting and inhibitory control are part of the earliest descriptions of children with Attention Deficit Hyperactivity Disorder (ADHD) (Hoffman, 1845). This chapter covers (1) the effects of fluctuating alertness levels and difficulties with inhibitory control on everyday life experiences of adolescents and adults with ADHD to provide real-life examples and context for the importance of studying these cognitive constructs. (2) Behavioural and (3) cognitive evidence investigating alertness and inhibitory control in participants with ADHD will be reviewed. (4) The theories of ADHD that highlight the effects of arousal/alertness and inhibitory control as key deficits associated with the disorder will be reviewed. (5) The biological underpinnings of alerting and inhibitory control will be examined, and (6) targeted therapies to help alleviate difficulties with alertness and inhibitory control will then be summarised.

Both alertness and inhibitory control need to be defined carefully as there are many descriptions available that vary subtly. First, we define alertness. Alertness and arousal are overlapping concepts. Arousal is observed as the non-specific activation of the brain during wakefulness. The term "alertness" is used to describe the behaviour of the participant as they are performing a task (Oken et al., 2006). Research into arousal and alertness processes help inform each other. Here we will focus on alertness, with research into and theories about arousal processes informing this review. Alertness is a description of the behaviour where a person is ready to respond. Alertness is essential for simple executive functions, including attention control and response inhibition (Calderon et al., 2016), and more complex executive functions. If a person is in a hypo- or hyper-alert state, this will have a detrimental effect on their attention control, their ability to inhibit distracting stimuli and stay on task, and their ability to perform higher-order cognitive tasks such as planning and rule-based decision-making. Researchers have described alertness in different ways. Sturm and colleagues argued that there are two subsystems of attention – one representing the intensity of attention, characterised as alertness and sustained attention, and the other representing the selectivity of attention, characterised as focused and divided attention (Sturm et al., 1997). In this theory, alertness is seen as the most basic form of attention that is required for each of the other, more complex, forms of attention (Sturm et al., 2004). A more recent consideration suggests that there are three

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forms of alertness – phasic, tonic, and intrinsic alertness (Unsworth et al., 2018). Phasic alertness is a short-term readiness to make a response, often after the participant has been provided with a warning signal that an event is about to occur. Tonic alertness is a baseline level of readiness, a general state of wakefulness, that is associated with one's circadian rhythm (Sturm & Willmes, 2001). Intrinsic alertness is one's voluntary readiness, derived from self-initiated preparation to respond (Robertson et al., 1997).

Like alertness, there are several ways to conceptualise inhibitory control, all of which characterise the ability to not respond to specific stimuli. Friedman and Miyake proposed a model of three separable forms of inhibitory control (Friedman & Miyake, 2004). The first is Prepotent Response Inhibition, which is the ability to suppress dominant, automatic, "prepotent" responses, and is measured using tasks such as the Anti-Saccade task, the Stop-Signal Response task, the Go/No-Go task, and the Stroop task. The second form is Resistance to Distractor Interference, which is the ability to ignore stimuli that have the potential to interfere with the task. Tasks such as the Eriksen Flanker task have interfering stimuli surrounding the target. The third form is Resistance to Proactive Interference, which occurs when a participant can ignore previously relevant information that has now been deemed irrelevant for the task. It is measured using tasks such as word memory tests where paired words are updated and previous pairings need to be ignored (Friedman & Miyake, 2004). These three forms of inhibitory control are reactive, in that the inhibition occurs after the appearance of the stimuli. Proactive inhibition is another form of inhibitory control in which undesired responses are prevented in advance of the appearance of stimuli (Perri, 2020). In this form of response inhibition, the goal of the behaviour is kept present in mind before the onset of the stimuli. Both reactive and proactive inhibitions can occur within the same experimental trial. Some researchers debate the need for this division into pro- and re-active inhibition, especially in the context of the role of attention in keeping control of goal-directed behaviour throughout experimental trials (Perri, 2020). Impulsive behaviours are conceptualised as the dual occurrence of a failure in inhibition and a strong drive (or impulse) to act (Bari & Robbins, 2013).

4.2 Everyday Life Experiences of Difficulties with Alertness and Inhibitory Control

Everyday life activities require the completion of tasks within quick succession. For instance, going shopping involves planning what to buy, deciding which shop is most suitable, navigating yourself to the shop, and finding the target products. In schools and workplaces, planning, remembering, navigating, directing attention, ignoring distracting stimuli, and dealing with new information occurs constantly. To complete such tasks, it is important to have adequate alertness levels and intact inhibitory control. Impairments in those functions can lead to adverse outcomes. Individuals with elevated levels of ADHD symptoms are reported to have difficulties with alertness and inhibitory control (Abramov et al., 2019; Murphy, 2002) (Woltering et al., 2013), and experience greater adverse outcomes in everyday life.

The mortality rate of individuals with ADHD is higher than the average in the population: 5.85 per 10,000 person-years in individuals with ADHD compared with 2.21 per 10,000 person-years in individuals without ADHD (Dalsgaard et al., 2015b). This is thought to be the result of increased rates of accidents and injuries. Accidental death is more common among people with ADHD than for those with no diagnosis (13.2% versus 4.3%) (London & Landes, 2016). ADHD is associated with a greater risk of experiencing injuries and accidents compared with typically developing people (Brunkhorst-Kanaan et al., 2021). Brunkhorst-Kanaan and colleagues noted that the types of common accidents associated with a diagnosis of ADHD change over the lifespan. In childhood, ingestion of foreign objects, poisoning, and fractures occur at a higher rate in those with ADHD compared with the average. In adulthood, there is a greater risk of having an accident – in traffic, in households, and in job-related settings (Able et al., 2007; Brunkhorst-Kanaan et al., 2021).

ADHD symptoms are linked to poor driving performance. People with ADHD are 2–4 times more likely to be involved in car crashes (Barkley & Cox, 2007; Chang et al., 2014; Philip et al., 2015). Driving performance in adults with ADHD was lower compared with adults without ADHD (Barkley & Cox, 2007; Sobanski et al., 2008). Adolescents with ADHD are at greater risk of being involved in road traffic accidents as pedestrians compared with matched controls (Clancy et al., 2006). Inattention and distractibility are two of the most common risk factors for car crashes in the general population (Lam, 2002). Difficulties with maintaining alertness and inhibitory control in adults with ADHD are associated with deteriorated performance in driving simulators (Bioulac et al., 2020). Lower alertness, due to task-induced fatigue, was associated with an increased risk of a driving accident, measured using both questionnaire and driving simulator data in adults with ADHD (Reimer et al., 2007). Other types of accidents are also observed more often in those with higher levels of ADHD. For instance, when totalling up accidents resulting in injury, damage, or a safety risk in the workplace, 13.9% of individuals with ADHD reported one or more accidents in the past year compared with 7.2% of other workers not diagnosed with ADHD, reported using self-report questionnaires (Kessler et al., 2009). The underlying cognitive mechanisms for these accidents and injuries are likely to be complex. Difficulties with alertness and inhibitory control associated with ADHD are two potential cognitive processes that increase the risk of these accidents and injuries.

A difficulty in maintaining appropriate levels of alertness is a risk factor for accidents and injuries in the general population. Lowered alertness is associated with increased occurrences of errors and accidents, and lowered alertness commonly occurs with sleep deprivation (Oken et al., 2006). Lowered alertness is associated with an increased risk of traffic accidents (George, 2007; Moradi et al., 2019; Otmani et al., 2005; Zhang & Chan, 2014). In a driving simulation study, an increase of incidents was associated with decreasing alertness levels, measured by subjective alertness from the Karolinska Sleepiness Scale and physiological alertness measured by blink duration (Åkerstedt et al., 2005). Children who had experienced non-fatal injuries from traffic accidents made more omission and commission errors on the Continuous Performance Task (CPT) compared with children without experiences of injuries from traffic accidents (Pless et al., 1995). Greater omission errors indicate dysfunction in tonic alertness and commission errors indicate difficulties with response inhibition, implying that lower alertness and response inhibition might have increased the risk of being involved in a traffic accident. Lower levels of alertness are also considered to be a major risk factor for accidents and injuries in the workplace (Folkard & Åkerstedt, 2004; Hosseinian & Torghabeh, 2012). These studies indicate how lower alertness can lead to greater risks of accidents in the general population.

Individuals with ADHD are more susceptible to distractions during driving, reflecting dysfunction in response inhibition associated with distractor interference (El Farouki et al., 2014; Pope et al., 2017; Reimer et al., 2010; Shaw et al., 2019). Accidents and injuries at home, work, and schools are linked with greater distraction and difficulty controlling interference in people with ADHD, as reported by questionnaires (Kittel-Schneider et al., 2019).

The adverse effects of dysfunction in alertness and inhibitory control in ADHD are not limited to accidents – they can also affect everyday activities in education and occupational settings. ADHD is associated with academic underachievement, including lower scores on tests measuring reading, writing, and maths performance, higher risk of dropping out of high school, and lower rates of attending higher education (Arnold et al., 2020; Barkley et al., 2006; Galera et al., 2009). Individuals with ADHD face occupational problems such as higher unemployment rates (Able et al., 2007; Klein et al., 2012) and difficulty in keeping jobs (Barkley et al., 2006). Biederman et al. (2006) conducted a telephone survey to examine the effect of ADHD and found that 34% of individuals with ADHD were employed full-time, which was lower than the 59% of respondents with full-time employment without ADHD (Biederman et al., 2006). These functional outcomes are thought to be due to the range of ADHD symptoms. Alertness and inhibitory control difficulties are also thought to contribute to these adverse outcomes. Lower alertness during work in people with ADHD was shown to have negative impacts on work performance and work behaviour, including more passive attitudes and passive leadership behaviours (Carleton & Barling, 2018; Verheul et al., 2015). Improvement in inhibitory control in people with ADHD undergoing cognitive training was associated with improved productivity in school and work, highlighting the importance of inhibitory control in those settings (Jensen et al., 2021). Deficits in inhibition are associated with higher unemployment rates in individuals with ADHD (Halleland et al., 2019). The effort to control distractible thoughts is an ongoing cognitive burden in the workplace for people with ADHD (Asherson, 2005). In daily activities in education and occupational settings, alertness and inhibitory control are important for optimal workplace performance.

Adverse outcomes can result from experiencing elevated levels of ADHD symptoms, and these can occur in various situations. These studies imply that optimal levels of alertness and inhibitory control help to avoid accidents and injuries in daily life and allow efficient work performance in educational and occupational settings.

4.3 Behavioural Evidence of Difficulties Associated with Alertness and Inhibitory Control

Direct observation is one research method used to measure problematic behaviours associated with ADHD. Behavioural observations can be carried out in more naturalistic situations than laboratories, most commonly in the classroom and workplace. The two most common behaviours that are observed in these types of studies are on-task and off-task behaviours. On-task behaviours are behaviours that indicate the person being observed is working on a specific task and engaging in expected behaviours such as reading and writing, self-initiated activity such as raising a hand, and other-initiated activity such as answering a question. In contrast, off-task behaviours are behaviours indicating that the observed person is not working on a specific task but may be talking to a neighbour or looking out of the window. In the classroom, off-task behaviours are reported to be greater in children with ADHD compared to children without ADHD (Abikoff et al., 2002; Antrop et al., 2000). A meta-analysis by Kofler et al. (2008) reported that students with ADHD were involved in off-task behaviours about 25% of class time compared with 12% in students without ADHD, suggesting that ADHD is associated with more frequent off-task behaviours (Kofler et al., 2008).

In the general population, alertness and inhibitory control are associated with frequency of off-task behaviours and thoughts. Students were suggested to be involved more in on-task behaviours when they were more alert (Broad et al., 2021). Increased self-reported off-task thoughts, which happen when a person is in an off-task state, are associated with decreased alertness during the performance of the task (Unsworth & Robison, 2016). The findings indicate that lower alertness levels can lead to a decrease in the time spent behaving on-task. The presence of distractors can disrupt attention to the task and increase off-task behaviours in the classroom, in which inhibitory control is required to suppress interferences from these distractions to focus on the task (Fisher et al., 2014). Better inhibitory control, measured by a Flanker task, is associated with less off-task behaviours in adolescents (Ludyga et al., 2022). Even though the underlying causes of off-task behaviours can be complex, these studies indicate that alertness and inhibitory control are involved in off-task behaviours.

In individuals with ADHD, deficits in alertness and inhibitory controls associated with off-task behaviours were shown in studies linking cognitive task performance and behaviours. Antonini et al. (2013) examined the relationships between some attention tasks and an observation of on-task behaviour during a maths test (Antonini et al., 2013). The study found that shorter duration of on-task behaviours was associated with greater response time variability measure by the tau parameter, which is thought to reflect lapses in attention. Another study tested the use of timers, which vibrate and remind students to monitor themselves and orient their focus to the task (Sluiter et al., 2020). The effect of the timer was examined by observing students' off-task behaviours and cognitive test performance before, during, and after an administration of the timer. The timer decreased the frequency of off-task behaviours and improved response inhibition, although improvements were not measured on the working memory and attention regulation tasks. These finding suggest that deficits in inhibitory control are associated with greater off-task behaviours in classroom. Another study by Johnson et al. (2020) observed on-task behaviours in the classroom and investigated how these behaviours related to cognitive task performance on a task of sustained attention and levels of ADHD symptoms rated by parents and teachers (Johnson et al., 2020). Children with high levels of ADHD symptoms were observed to show less on-task behaviours in the classroom. More on-task behaviour was associated with a smaller number of commission errors indicating better inhibitory control, and it was also associated with a smaller number of omission errors indicating lapses in attention and lower alertness to the task.

4.4 Cognitive Evidence of Difficulties Associated with Alertness and Inhibitory Control

In psychological research, cognitive tasks are designed to measure specific cognitive constructs. Target stimuli are presented, and participants are often asked to respond to the stimuli, where the stimuli and rules of responding are modified based on what cognitive construct is being measured. Task performance is then considered a measure of the cognitive construct, and accuracy and speed of the response are the most common measures.

For evaluating phasic alertness, warning cues are commonly used. The presence of a warning cue preceding the appearance of the target stimuli can quicken response times compared with a condition without warning cues (Rodway, 2005). Children with ADHD show deficits in response to alerting cues (Johnson et al., 2008; Mullane et al., 2011; Oberlin et al., 2005). ADHD appears to be associated with difficulties in increasing phasic alertness and readiness to prepare for upcoming stimuli.

Impairments in tonic alertness have also been reported in ADHD. Tonic alertness can be measured using a few different parameters. Omission errors, a failure to respond to Go stimuli, are thought to reflect lapses of attention and vigilance. Meta-analyses indicate that individuals with ADHD make a greater number of omission errors compared with individuals without ADHD when performing response inhibition tasks such as the Go/No-Go (Willcutt et al., 2005; Wright et al., 2014). Another measure that reflects tonic alertness is performance over time, where tonic alertness is thought to help maintain performance over the course of the task and mitigate deterioration of performance. Individuals with ADHD showed greater decrements in performance over time, as measured by omission errors, commission errors, general speed of response time, and response time variability (Huang-Pollock et al., 2012). These findings suggest that ADHD is associated with difficulties in maintaining alertness to meet and keep up with the demands of the task.

Response inhibition is the ability to withhold or cancel a response to non-target stimuli. The ability to cancel an initiated response is often measured by the Stop Signal task, where participants need to inhibit their responses when a stop stimulus appears very soon after a Go stimulus. The stop signal reaction time is an estimate of time taken by the inhibitory process. Lipszyc and Schachar (2010) performed a meta-analysis of papers using the Stop Signal task, and they showed that individuals with ADHD have difficulties in response inhibition to cancel initiated responses, estimated to have a medium effect size (Lipszyc & Schachar, 2010). The ability to withhold responses that are not yet initiated is often measured using variants of the Go/No-Go task. A failure to inhibit responses to No-Go stimuli is called a commission error and is a measure of response inhibition. A meta-analysis of Go/No-Go tasks showed that individuals with ADHD are more likely to produce commission errors, suggesting dysfunction in response inhibition (Wright et al., 2014). Another meta-analysis testing both cancellation of a response and withholding a response also showed differences in the stop signal reaction time and commission errors between individuals with and without ADHD with moderate effect sizes (Willcutt et al., 2005). These studies suggest that ADHD is associated with dysfunctions in response inhibition, irrespective of the type of response inhibition (cancellation and withholding).

Distracter interference/interference control is the ability to control distractions and interferences unrelated to the task. The Flanker task and Simon task are common cognitive tasks that measure interference control by comparing conditions with and without the presentation of task irrelevant information, or the presence of congruent or incongruent stimuli flanked to the target. Greater interference will result in more errors and slower responses during the incongruent trials compared with congruent trials. The systematic review by Mullane et al. (2009) reported that ADHD is associated with more errors and slower responses when greater interference is present (Mullane et al., 2009). The findings suggest that individuals with ADHD have more difficulty in controlling distractions and interference that is irrelevant to the task.

The third form of inhibition is the control of memory interference, where previously relevant information that is no longer relevant for the current task needs to be controlled. The meta-analysis by Orban et al. (2022) showed that individuals with ADHD react to memory interference differently depending on types of memory interference (Orban et al., 2022). Compared with individuals without ADHD, individuals with ADHD were more affected by retroactive interference, where recent information interfered with the process of recalling previously learned information, with a small effect size. In contrast, children with ADHD were less affected by proactive interference, where prior learning interfered with recalling recent information. In adults with and without ADHD, there was no significant difference in proactive interference. The authors speculated that individuals with ADHD are recalling less information, and thus less memory interference may be occurring. Control of memory interference may be intact in ADHD in terms of proactive interference and more affected by retroactive interference, but the effect size is small.

Among the three forms of inhibition (response inhibition, distractor interference, and proactive memory interference) formulated by Friedman and Miyake (2004) (Friedman & Miyake, 2004), ADHD groups exhibited dysfunction in response inhibition and distractor interference, but memory interference seemed less affected.

4.5 Theoretical Perspectives on Alertness and Inhibitory Control

Theoreticians from the 1970s and 1980s highlighted difficulties with sustained attention, inhibitory control, and alertness as key deficits associated with the disorder. Virginia Douglas argued that the abilities to sustain attention and control impulsivity were the core symptoms of the disorder (Douglas, 1972). She also highlighted a reduced phasic alerting response in hyperactive children – this phasic response helps the participant to be more sensitive to stimuli. She noted no difference was found in the tonic alerting response between groups. She referenced Kagan’s work showing that children who were more impulsive in their cognitive profile were also more distractable, less attentive, and more physically active than their core reflective peers (Kagan et al., 1964). Children with ADHD seem to be unusually disrupted by partial reinforcement schedules and habituate to rewards more quickly that control children (Douglas, 2005). In her later writings, she suggested that the symptoms of ADHD are better conceptualised as deficits in self-regulation, with three components – attention, inhibition, and strategic or organisational (such as preparation, planning, working memory, set-shifting) (Douglas, 2005).

Following on with the focus on executive dysfunction, Barkley, and others (Schachar et al., 1993), proposed that behavioural inhibition is the key characteristic associated with the disorder (Barkley, 1997). Based on neuropsychological theory, Barkley proposed that four secondary features would also be associated with the disorder as they are reliant on inhibition for strong functioning. He reviewed the literature and found evidence of support for dysfunctions in working memory, regulation of motivation, and motor control.

Zentall and Zentall proposed the Optimal Stimulation Theory of ADHD, which is based on homeostatic principles. This theory suggests that organisms need an appropriate amount of sensory stimulation. Where this amount is not available then the person's activity level will then be modified to provide the right amount of stimulation for that person (Zentall & Zentall, 1983). The theory suggested that children with hyperactivity experience suboptimal levels of stimulation, leading to low levels of arousal, and so compensate with hyperactive behaviours to build arousal to an appropriate level. The inattentiveness associated with the disorder is directly related to the seeking of more environmental stimuli, with a preference for new, novel stimuli rather than repetitive, familiar stimuli. To gain the optimal level of stimulation, hyperactive children would move more, look around more, and talk more. "Hyperactive children are unusually sensitive to low-stimulation environments or repetitive tasks" (p.453) (Zentall & Zentall, 1983).

The Cognitive-Energetic framework of information processing efficiency was developed by Sanders (1983). Cognitive efficiency is a process involving stimulus encoding, memory search, decision-making, motor preparation, and execution. Energy is needed for this system to work, and the theory suggests that arousal and activation regulate cognitive efficiency. Effort is also needed to meet task demands and compensate for sub-optimal levels of arousal and activation (Sanders, 1983). In this theory, arousal is divided into phasic arousal, which affects stimulus input into the system (stimulus encoding) and tonic activation, which affects output processes (motor preparation). A regulatory system oversees these processes to ensure that energy is distributed where needed for the task at hand. The cognitive system functions at an optimal level with the right amount of arousal/activation and can have too little and too much arousal/activation, negatively affecting performance (Sonuga-Barke et al., 2010). The State Regulation Deficits theory (Van der Meere & Sergeant, 1988) is based on the Cognitive-Energetic framework. According to this theory, the symptoms of ADHD are related to a failure in regulating the energetic state (arousal/activation). Research by van der Meere and Sergeant determined that the stimulus encoding, memory search, decision-making processes, and the phasic arousal system were largely intact in ADHD, while the motor preparation process and the tonic activation system, which affects motor preparation and readiness for action, were areas of deficit (Sergeant, 2005). Task characteristics, such as too fast or slow event rates, would lead to characteristic responses from a group with ADHD, such as too fast or slow responses, respectively, and inaccurate responding (Sonuga-Barke et al., 2010). People with ADHD may compensate for under-activation by seeking additional stimulation through movement and flitting of attention (Sonuga-Barke et al., 2010).

Motivational factors may also play a role in the symptoms associated with the disorder. An aversion to delay of reward has been long described as a symptom of ADHD (Sonuga-Barke et al., 1992), with a preference for smaller rewards sooner rather than larger rewards later. These are considered as impulsive choices. Even in temporal discounting tasks, children with ADHD discount larger later rewards at a higher rate than smaller sooner rewards, particularly when the delay to wait was longer, at 25 s, than shorter, at

13 s (Yu et al., 2018). The theory holds that future rewards, signalled by the dopamine system within the brain reward circuits (orbito-frontal cortex and the ventral striatum), are altered in ADHD (Sonuga-Barke et al., 2010; Sonuga-Barke, 2003), leading to an impulsive drive for an immediate reward. Over time, any delay becomes associated with negative affect, censure from others, and a sense of failure, becoming a powerful driver for the preference for immediate rewards (Sonuga-Barke, 2003).

The Dynamic Developmental Theory of ADHD is based within the tradition of behaviourism (Sagvolden et al., 1998). The theory suggests that ADHD is associated with altered dopaminergic functioning that leads to inappropriate noradrenaline modulation. The theory suggests three dopamine system branches are affected in ADHD, each with lower-than-expected levels of dopamine. Hypoactivity in the mesolimbic dopamine system is thought to lead to a steepened delay–reward gradient in reinforcement of behaviour and deficient extinction of previously reinforced behaviour. The symptoms of poor sustained attention, impulsiveness, delay aversion, hyperactivity in novel situations, and disinhibition are the result of this hypo-dopamine state (Sagvolden et al., 2005). Low levels of dopamine within the mesocortical dopamine system are hypothesised to be associated with difficulties orienting attention, impaired saccadic eye movements, and poor executive functioning. Hypofunctioning of the nigrostriatal dopamine branch is associated with impairment in motor functioning, habit learning, and memory, leading to motor clumsiness, neurological “soft signs”, and response inhibition difficulties.

4.6 Neurobiological Evidence of Alertness and Inhibitory Control

Alerting is modulated by several brainstem systems. The bodies within the brainstem involved in alerting, vigilance, mood, and cognition are the dorsal Raphe nucleus (serotonergic), the locus coeruleus (noradrenergic), the midbrain ventral tegmental area and the substantia nigra compacta (dopaminergic) (Sara & Bouret, 2012). These cell bodies project into the cortex in a widespread manner, and they are well interconnected. The locus coeruleus plays an important alerting role. It is the sole source of noradrenergic innervation to the subcortical and cortical regions of the brain. Noradrenalin strongly influences arousal and sensory processing (Sara & Bouret, 2012); activity in the locus coeruleus neurons tracks with the sleep–wake cycle and levels of vigilance (Alnæs et al., 2014; Aston-Jones et al., 1999; Berridge et al., 1993). Noradrenalin may be particularly important in helping to rapidly change attention focus and behavioural responses (Sara & Bouret, 2012). The influence of noradrenalin on prefrontal cortex activity follows an inverted U-shape, where too little or too much of this neurotransmitter results in suboptimal cognitive performance (Aston-Jones & Cohen, 2005).

There are a few measures of alertness that provide insight into the neurobiology of this behaviour. The diameter of the pupil (Unsworth & Robison, 2016; Unsworth et al., 2018; Van den Brink et al., 2016) is one important measure. The locus coeruleus in the brainstem releases noradrenalin throughout the neocortex, and both pupil size (Alnæs et al., 2014; Joshi et al., 2016) and participant-reported arousal vary as a response (Alnæs et al., 2014; Morris et al., 2020). The causal nature of the activity of the locus coeruleus and pupil size is debated; the anatomical connections between the locus coeruleus and the brainstem nuclei regulating pupil size in macaque monkeys are not clear (Costa & Rudebeck, 2016). There may be additional roles of serotonin in regulating pupil dilation (Joshi, 2021), and of the pretectal olivary nucleus that controls of the pupillary light reflex and the superior colliculus that mediates orienting responses (Joshi & Gold, 2020). Apart from pupil size, there are further physiological measures of alertness. The galvanic skin response (electrodermal skin conductance) (Montagu & Coles, 1966), and heart rate and heart rate variability are used as measures of alerting. Accelerations and decelerations of HR are associated with levels of alertness and arousal (Azarbarzin et al., 2014). Behaviourally, alertness can be measured by changes in response time and error rate when a participant has been alerted by a stimulus, such as a flash of light or a sound, right before the appearance of an informative cue and the target (Posner, 2008). Questionnaires can be used for directly asking the participant how alert they feel such as the Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990).

In ADHD, there is evidence to suggest that the levels of alertness are lower than are expected (Bellato et al., 2020). Larger pupil diameters have been found in participants with ADHD compared with controls (Nobukawa et al., 2021; Shirama et al., 2020). Baseline galvanic skin response levels are lower during baseline periods, before task activation, in people with ADHD compared with matched controls (James et al., 2016). Behaviourally, children with ADHD show deficits in the response to alerting cues (Johnson et al., 2008; Mullane et al., 2011; Oberlin et al., 2005). For a recent review, see Bellato et al. (2020).

The decision to respond or stay still is a complex one. Information is perceived by our senses, and our association cortices help to process and prioritise these stimuli. The inferior temporal cortices process sensory information, determine what is being perceived, and can be used to filter the information for characteristics of interest to the person. The posterior parietal cortex processes visual stimuli for where they are appearing, if they are moving, and helps orient attention in time and space (Arnsten & Rubia, 2012). The prefrontal cortex provides top-down regulation of attention based on the goals of the person. Irrelevant stimuli are inhibited, and attention is regulated so that we stay on task. The parietal and prefrontal cortices are interconnected and work together to orient and maintain attention to important stimuli over time. These cortical areas are linked to the caudate nucleus of the basal ganglia, the thalamus, and back to the prefrontal cortex (Alexander et al., 1986). The prefrontal and parietal cortices are also linked to the cerebellum via the pontine nuclei (Middleton & Strick, 2000; Middleton & Strick, 2002). Decisions to act are made, and instructions are sent from the prefrontal cortex to the basal ganglia, the thalamus, the supplementary motor area, and the motor cortex for action.

A number of areas are involved in impulse control and motor inhibition, interference control, and cognitive flexibility, particularly the inferior frontal cortex (and particularly the right side) (Aron et al., 2003; Chambers et al., 2009) and the pre-supplementary motor area (Bari & Robbins, 2013). The dorsolateral prefrontal cortex, the anterior cingulate, the supplementary motor area, the superior temporal gyri, the parietal cortex, the insula, the basal ganglia, cerebellum, the frontal eye fields, and the supplementary eye fields are also involved in inhibitory control (for recent review see (Borgomaneri et al., 2020)). Within the basal ganglia there are complex circuits set up to aid selection of behaviours, motor planning, and the motor response (for recent reviews see (Isherwood et al., 2021; Park et al., 2020)). The specific roles played by these brain areas, under different task conditions, is an area of active research.

In ADHD, the brain circuitry associated with response inhibition shows altered functioning during functional magnetic resonance imaging (MRI) and in structural MRI analyses. During failed inhibition, hypoactivity was noted in the ventro- and dorso-lateral prefrontal cortices (Braet et al., 2011; Rubia et al., 2009), in the insula and anterior cingulate cortex (Janssen et al., 2015), and the premotor cortex (Pliszka et al., 2006). When participants with ADHD successfully inhibited a response, greater activation compared with controls was noted in the temporal and parietal cortices (Pliszka et al., 2006), the superior frontal cortex, the ACC, insula, and the occipital cortex (Janssen et al., 2015; Pliszka et al., 2006; Rubia et al., 2009), the prefrontal cortex, the thalamus, and nucleus accumbens (Costa Dias et al., 2013) (for recent review see (Puiu et al., 2018)). From a structural perspective, deficits are mostly prominent in the subcortical areas including the basal ganglia and the insula (Hoogman et al., 2017; Rubia, 2018), but alterations are also seen in the ventromedial prefrontal cortex (Norman et al., 2016), the anterior cingulate cortex, the insula, and the temporal and parietal lobes (Puiu et al., 2018).

4.7 Targeted Therapies for Alertness and Inhibitory Control

There are a few different ways to mitigate the adverse effect of ADHD symptoms. Medication/pharmacological treatment is the most common treatment for ADHD. Stimulants, such as methylphenidate and dexamphetamine, have been shown to be more effective in reducing ADHD symptoms compared with non-stimulants, such as atomoxetine (Faraone & Glatt, 2010), and are therefore more widely used for symptoms associated with ADHD. Stimulants increase levels of neurotransmitters such as dopamine and noradrenaline in the brain by blocking the reuptake of these neurotransmitters within synaptic clefts. These medications improve inhibitory control (Illieva et al., 2015) and help to increase alertness (Boutrel & Koob, 2004). Functional outcomes are also improved. ADHD medications, mostly stimulants, helped reduce the risk of traumatic brain injury (TBI), motor vehicle crashes, accidents, and injuries including bone fractures, poisoning, burns and others (Boland et al., 2020; Liou et al., 2018). Compared with non-treated ADHD males, there is a 29% reduction of traffic accidents in males treated for ADHD (Chang et al., 2014). Driving performance in adults with ADHD improved with medication treatment, helping to reduce traffic accidents (Biederman et al., 2012; Sobanski et al., 2008). When treated for ADHD, the risk of injuries was reduced by 43% and emergency visits by 45% (Dalsgaard et al., 2015a). Reduced inhibitory control and reduced alertness are associated with greater risks of involvement in accidents; improved inhibitory control and alertness due to medication usage may be associated with a reduction in accidents and injuries (Aduen et al., 2020; Barkley & Cox, 2007). Medication treatment can improve alertness and inhibitory control in ADHD, and it can lower the risks of being involved in accidents and injuries.

Medication treatment was also shown to help in education and workplaces. ADHD medication helped with academic outcomes, leading to improved academic achievement observed by higher scores on reading, spelling, and math, higher school grades, and higher rates of completing degrees (Arnold et al., 2020). Behaviourally, medication treatment was effective in increasing alertness and improving on-task behaviours in the classroom (Prasad et al., 2013). These findings indicate that medication is helpful in reducing functional impairments individuals with ADHD face in everyday life.

One of the common non-pharmacological treatments is behavioural and/or cognitive therapy. Cognitive Behavioural Therapy (CBT) is effective in improving ADHD symptoms. A combination of medication and CBT results in superior outcomes compared with medication or CBT alone (Arnold et al., 2016). Most CBT treatments for ADHD are highly structured and manualised, and are therefore consistent across clinicians, allowing for comparison across studies. CBT-based programmes attempt to teach organisational and time-management skills, problem-solving, impulsivity control, emotional regulation, and attention control (Kooij et al., 2019). This non-pharmacological intervention also improves academic outcomes in students with ADHD, leading to better grades and completion (Arnold et al., 2020). Cognitive training, another non-pharmacological intervention, involves adaptive and repeated training, practice, and feedback. Cognitive training is also associated with improved inhibitory control, as assessed by the number of commission errors made on a Go/No-Go task (Kofler et al., 2020).

Physical activity is another non-pharmacological treatment. Physical activity and aerobic exercise have positive impacts on cognition, especially processing speed, memory, and executive functions (Hillman et al., 2008; Stillman et al., 2020). People with a wide variety of clinical disorders receive benefits from increased physical activity and exercise, including those with ADHD (Erickson et al., 2019). Aerobic exercise improves executive functioning/inhibitory control and inattention symptoms in ADHD (Cerrillo-Urbine et al., 2015; Ng et al., 2017). Thirty minutes of high-intensity exercise was associated with improved vigilance and response inhibition, as measured by CPT performance, implying improvements in alertness and inhibitory control (Medina et al., 2010). Physical exercise is associated with improved inhibitory control (Vysniauske et al., 2020). This meta-analysis found that a longer duration of exercise intervention is linked with a greater positive effect size but that the intensity of exercise does not influence the effect size. The authors suggest that moderate exercise is enough to have a positive effect on inhibitory control and that regular exercise is associated with a better effect for individuals with ADHD. A meta-analytic comparison of different non-pharmacological treatments for ADHD found that physical exercise has the largest effect size, followed by Cognitive Behavioural Therapy (CBT), biofeedback, and cognitive training (Lambez et al., 2020). The study also examined which cognitive functions are improved by non-pharmacological treatment regardless of treatment type, finding that inhibitory control improved the most.

Engaging in more physical activity and exercise is also beneficial for members of the general population. Inhibitory control improves after exercise, as assessed by a Flanker task (Gejl et al., 2018). A modest effect of chronic exercise was also reported by a meta-analysis combining Stroop, Flanker, and Go/No-Go tasks, which showed better accuracy with engagement of physical exercise (Amatriain-Fernández et al., 2021). Alertness can also be improved with exercise. The acute effects of exercise, such as 20 min of walking, resulted in improved inhibitory control, as measured by a Flanker task, and increased phasic alertness, measured by pupil dilation (Shigeta et al., 2021). Exercise helped participants to cope with sleepiness and helped participants feel more alert after overnight work shifts (Barger et al., 2021; Barger et al., 2004). The beneficial effect of exercise can be observed in various populations with and without clinical disorders; engaging in exercise is associated with improvements in inhibitory control and alertness.

In everyday life, there are situations where acute treatment is required to avoid accidents or recover performance by maintaining alertness such as after sleep loss. Lower alertness and fatigue can lead to inconsistent and inaccurate performance, and difficulties with multi-tasking and producing efficient performance (Caldwell et al., 2008). Fatigue could be due to sleep deprivation, tiredness, or related to the task itself, which may be tedious and hard to perform (Caldwell et al., 2008). There are a few different strategies to improve alertness and mitigate fatigue. Taking a nap for short period of time can mitigate sleepiness and improve alertness, which can recover your performance (Rosekind et al., 1995). Caldwell et al. (2008) suggested placing limits on the time spent on a task, preparing time for breaks, and adjusting the brightness of lights (Caldwell et al., 2008). Adjusting the room temperature and engaging in physical activities such as stretching and walking also help fight declining alertness (Sagah Zadeh et al., 2018). These acute treatments help to mitigate fatigue and maintain alertness, so performance can be recovered, and potential negative consequences can be avoided. There are also strategies that employers can take to help individuals who have difficulties with inhibitory control by changing the work environment. Adamou et al. (2013) provided a few suggestions for employers (Adamou et al., 2013), including reducing distractions, allowing employees to easily control distracting interference such as the use of a private office or quieter rooms, and providing staff with flexible working hours that allow them to work during quieter hours of the day. The use of alarms and structured notes can also be helpful. Regular meetings, frequent feedback, and setting small targets and goals are beneficial in time management and completing tasks on time. Allowing productive movements and inserting breaks in long meetings can help maintain alertness during working hours.

4.8 Conclusion

In summary, individuals with ADHD face greater risks of functional impairments in life, which include higher risks of being involved in accidents and injuries, and more difficulties in educational and occupational situations to perform tasks. Observations and ratings of behaviours are used to evaluate levels of ADHD symptoms. Behavioural observations showed that students with ADHD exhibit more off-task behaviours than students without ADHD, suggesting difficulty in maintaining attention to tasks. By using cognitive tasks, performance decrements in individuals with ADHD have been reported across multiple tasks testing alertness and inhibitory control. The theories of ADHD highlight alertness and response inhibition as core symptoms of the disorder. Neurological evidence suggests that wide areas of the brain are involved in tasks testing alertness and inhibitory control. People with ADHD showed hypoactivation in brain circuits associated with alertness and inhibitory control. Several treatments are available for ADHD. The most used and effective treatment is to use stimulant medication, which successfully reduces the risks of various functional impairments and mitigates dysfunction in alerting and inhibitory control.

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5 Executive Functions and Emotional Lability in Adults with ADHD

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5.1 ADHD

Attention deficit hyperactivity disorder (ADHD) is the most prevalent neurodevelopmental disorder in childhood. The DSM-5 (American Psychiatric Association, APA, 2013) places ADHD in the Neurodevelopmental Disorders section. Diagnostic criteria A (frequency and developmental deviance of symptoms) is defined by a list of 18 symptoms that are evenly divided between inattentive and hyperactive/impulsive domains. For diagnostic purposes, the number of inattentive and hyperactive-impulsive symptoms must be above the threshold, the frequency and severity of inattention and hyperactivity-impulsivity must be atypical or developmentally outside the range of normal variation expected for age and gender, and these symptoms must have been present for the past 6 months or longer. There must also be evidence of significant symptoms of inattention and/or hyperactivity-impulsivity before the age of 12 years, usually in early or middle childhood (criterion B, age of onset), although some individuals may receive clinical attention later. Manifestations of inattention and/or hyperactivity-impulsivity must be evident in multiple situations or settings (e.g., home, school, work, with friends or with family: Criterion C, pervasiveness). However, they are likely to vary according to the structure and demands of the environment. There must also be clear evidence that these symptoms interfere with, or reduce the quality of, daily functioning (criterion D). The two symptom domains yield three possible presentations of ADHD: predominantly hyperactive/impulsive presentation, predominantly inattentive presentation, and combined presentation.

The relative balance and specific manifestations of the characteristics of inattention and hyperactivity-impulsivity vary from individual to individual and may change over the course of development. There have been some changes in DSM-5 that are relevant to diagnosis in adults. Previous diagnostic A criteria required the presence of six out of nine symptoms in either of the symptom domains as the diagnostic threshold for individuals of all ages. This remains the threshold for children and adolescents. The cutoff for adults has been lowered to five out of nine symptoms because some symptoms are less applicable to adults, and a lowered threshold is a better marker of developmental deviance in adults (Barkley

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et al., 2002). The recently updated 11th edition of the International Classification of Diseases (ICD-11; World Health Organization, 2018) uses the term ADHD and the same three presentation types and age-of-onset criteria as DSM-5.

ADHD prevalence ranges between 5% and 7% (Polanczyk et al., 2014; Thomas et al., 2015) in childhood/adolescence; the prevalence in adulthood is estimated to be between 2.5% and 4% (APA, 2013; Fayyad et al., 2017; Simon et al., 2009).

About one-third of children and adolescents have persistent symptoms of ADHD into adulthood (Faraone et al., 2006; Simon et al., 2009). Estimates of adult ADHD persistence range between 4.0% and 77.0%, depending on the method of diagnosis. When the diagnosis included collecting information from multiple informants (e.g., self and other), required the presence of impairment, and used an age-appropriate symptom threshold, the persistence rates decreased to 40–50% (Sibley et al., 2016).

The severity of the disorder in the adult population is associated with multiple negative consequences: academic underachievement (significantly lower levels of education and higher university dropout); lower socioeconomic status; family, social, and professional problems (e.g., a greater number of unstable partnerships, frequent job dismissals, and more frequent car accidents and mortality); and more detentions and incarcerations (Biederman et al., 2006; Biederman et al., 2012; Dalsgaard et al., 2015; Mannuzza et al., 2008).

Several studies have cited the phenomenon of adult-onset ADHD (Agnew-Blais et al., 2016; Caye et al., 2016; Moffitt et al., 2015) because there are cases in which the diagnosis of ADHD is made de novo in adulthood. The notion of adult-onset ADHD stems from studies that use retrospective assessment of childhood symptoms, along with assessment of current symptoms, and document the presence of ADHD in adults with no previous evidence of any symptoms of ADHD in childhood.

A typical adult with ADHD is either an individual diagnosed in childhood who continues to manifest clinical symptoms in adulthood or an individual who was not identified with ADHD until adulthood, for whom the presence of symptoms in childhood is established retrospectively during the clinical assessment (Ramsay, 2017). Sibley et al. (2018) assessed 239 participants who were part of the local normative comparison group of the Multimodal Treatment Study of ADHD. Participants were administered eight assessments from comparison baseline (mean age = 9.89 years) to young adulthood (mean age = 24.40 years). Diagnostic procedures utilized parent, teacher, and self-reports of ADHD symptoms, impairment, substance use, and the presence of other mental disorders, with consideration of symptom context and timing. The results indicated that adult-onset of ADHD may be valid in some cases. However, more commonly, there is no impairment of cognitive fluctuations. Symptoms represent a comorbid disorder or the cognitive effects of substance use rather than ADHD itself. Another study by Ahmad et al. (2019) failed to find evidence supporting adult-onset ADHD in a longitudinal sample of women with similar alternative explanations for emerging attention deficits.

The clinical practice standard continues to be a thorough review of symptom onset and persistence in all adult cases, including retrospective accounts of subthreshold symptoms of ADHD or difficulties in childhood for which the treatment was not sought until adulthood because of attenuating factors (e.g., intelligence, good educational practices, emotional and educational support, or dismissive attitudes toward diagnosis; Kooij et al., 2019; Ramsay, 2017). These cases are better referred to as late-identified rather than adult-onset.

5.2 Comorbidity

There is an extensive body of research suggesting that ADHD in adulthood continues to show high rates of comorbidity with other adult mental health disorders. Between 37% and 89% of adults with ADHD endure one or more additional comorbid psychiatric conditions (Katzman et al., 2017; Olsen et al., 2012; Sobanski, 2006). For instance, Ohnishi et al. (2019) reported, in a sample of adult patients with ADHD, that more than 50% had at least one comorbid condition. Of those, 40% had two or more comorbid conditions. The symptoms and conditions that co-occur with ADHD include disorders associated with internalizing and externalizing symptom domains (e.g., Jacob et al., 2013; Oguchi et al., 2021). Regarding the internalizing symptoms, clinical studies have documented a high prevalence of dysthymia/depressive disorders (18.6–53.3%), bipolar disorders (2–15%; Di Lorenzo et al., 2021), anxiety disorders (12.17–50%) (Chen et al., 2018; Katzman et al., 2017; Oguchi et al., 2021; Ohnishi et al., 2019), and cluster C personality disorders (PDs) (36.6%; Matthies et al., 2011). In particular, in this cluster, the most common conditions are obsessive compulsive (14–27.58%) and avoidant (12.54–21.7%) PDs (Cumyn et al., 2009; Matthies et al., 2011; Miller et al., 2007). In addition, elevated rates of externalizing symptoms are consistently reported, with a high prevalence of cluster B PDs (23.3%; Matthies et al., 2011), most frequently, borderline (18.3–33.6%), narcissistic (12–25.16%), and antisocial (11.3–23%) PDs (Cherkasova et al., 2022; Jacob et al., 2013; Katzman et al., 2017; Matthies et al., 2011; Miller et al., 2007). In addition, externalizing behaviors such as substance use disorders (SUDs; Patrick et al., 2016) have a high comorbidity with ADHD in adults (35.12%; Chen et al., 2018; Ohnishi et al., 2019). Another aspect to be noted is that predominantly inattentive ADHD (ADHD-PI) has elevated comorbidity with dysthymia, depression, and anxiety disorders, while predominantly hyperactive-impulsive (ADHD-HI) and combined (ADHD-C) presentations have considerable comorbidity with cluster B personality disorders (Jacob et al., 2013; Miller et al., 2007; Ohnishi et al., 2019). To sum up, psychiatric comorbidities that co-occur with ADHD in adults often overlap with common features of ADHD, which might account for at least one co-occurring psychiatric disorder (e.g., Jacob et al., 2013) (see Table 5.1). Specifically, internalizing and externalizing symptoms rooted in anxious and impulsive-disinhibited temperament traits (Paris, 2003), respectively, reflect cognitive and behavioral deficits that rely on the mechanisms underlying executive functioning and emotion regulation (e.g., Diamond, 2013), which also account for some core symptoms of ADHD (e.g., Miller et al., 2007). For instance, studies show that ADHD and cluster B PDs (e.g., borderline PD) share conceptually similar symptoms in terms of problems for regulating emotion, behavior, and cognition. This suggests that ADHD and cluster B PDs presumably share similar personality diatheses, which increase the probability of co-occurrence between them (e.g., Miller et al., 2007). In addition, the evidence suggests that there are shared genetic influences between executive functioning and some PDs (e.g., avoidant, borderline, dependent, depressive, and histrionic) (Coolidge et al., 2004). As seen in Table 5.1, ADHD and coexisting disorders such as, for example, anxiety, bipolar disorders, or borderline PD share symptoms linked to emotional dysregulation and problems in executive control (e.g., Akbari et al., 2019; Dickinson et al., 2017; Kernberg & Yeomans, 2013; Meinzer et al., 2016; Moukhtarian et al., 2018; Zhang et al., 2021). Here, it is important to note that some co-occurring disorders can be considered more as a complication of ADHD (Asherson et al., 2016).

5.3 Executive Functions and ADHD

Executive functions (EF) are defined as "functions that serve as an integrative directive system exerting regulatory control over basic, domain-specific neuropsychological functions (e.g., language, visuospatial functions, memory, emotional experience, motor skills) in the service of reaching an intended goal" (Gioia & Isquith, 2004, p. 139).

EFs have been grouped into cold and hot domains (Zelazo & Müller, 2002). Cold EFs involve cognitive/top-down processing and encompass a broad range of core processes such as inhibition, working memory, cognitive flexibility, and planning (Diamond, 2013; Goldstein et al., 2013; Miyake et al., 2000). Hot EFs involve emotion regulation, reward/top-down processing,

Table 5.1 EF and emotional dysregulation deficits of major psychiatric conditions that co-occur with ADHD

	Externalizing behaviors					Internalizing behaviors						
		Cluster B				Cluster C						
		Dramatic, emotional or erratic cluster				Anxious or fearful cluster						
ADHD symptoms and related deficits	Bipolar disorders	Borderline PD	Narcissistic PD	Antisocial PD	Histrionic PD	Avoidant PD	Dependent PD	Obsessive-compulsive PD	Anxiety	Depression	Substance -use disorder	Study
Inattention hyperactivity/ impulsivity		X	X		X	X						Jacob et al. (2013)
	X	X	X			X		X	X	X	X	Katzman et al. (2017)
		X	X		X	X	X	X				Matthies et al. (2011)
			X	X	X							Matthies and Philipsen (2016)
	X							X	X	X	X	Ohnishi et al., 2019
Emotional dysregulation		X										Ditrich et al. (2021)
											X	Koob and Volkow (2016)
			X									Lowenstein et al. (2016)
	X									X		Mesbah et al. (2021)
		X		X								Nilsson et al. (2016)
								X				Pinto et al. (2014)
						X	X					Smesny et al. (2018)
					X							Soloff (2018)
									X			

												Zhang et al. (2021)
CEF/Working memory				X							X	Baskin-Sommers et al. (2022)
			X		X	–						Burgess (1992)
	X											Dickinson et al. (2017)
								X				Garcia-Villamisar et al. (2017)
		X										Hagenhoff et al. (2013)
							X					Spinhoven et al. (2009)
									X	X		Zhang et al. (2021)
CEF/flexibility				X							X	Baskin-Sommers et al. (2022)
	X											Dickinson et al. (2017)
								X				Fineberg et al. (2015)
		X										McClure et al. (2016)
			X									Ronningstam and Baskin-Sommers (2013)
									X	X		Zhang et al. (2021)
CEF/inhibition		X										Akbari et al. (2019)
				X							X	

(continued)

Table 5.1 (continued)

	Externalizing behaviors					Internalizing behaviors						
		Cluster B				Cluster C						
		Dramatic, emotional or erratic cluster				Anxious or fearful cluster						
ADHD symptoms and related deficits	Bipolar disorders	Borderline PD	Narcissistic PD	Antisocial PD	Histrionic PD	Avoidant PD	Dependent PD	Obsessive-compulsive PD	Anxiety	Depression	Substance -use disorder	Study
												Baskin-Sommers et al. (2022)
	X											Dickinson et al. (2017)
								X				Garcia-Villamisar et al. (2017)
			X									Vazire and Funder (2006)
									X	X		Wright et al. (2014)
CEF/planning		X										Akbari et al. (2019)
				X							X	Baskin-Sommers et al. (2022)
			X		X							Burgess (1992)
	X											Dickinson et al. (2017)
								X				Fineberg et al. (2015)
									X	X		Zhang et al. (2021)
HEF Decision-making						X						Berenson et al. (2021)

emotional processing	X											Clark and Sahakian (2008)
			X									Coleman et al. (2022)
				X								De Brito et al. (2013)
											X	Murphy et al. (2012)
		X										Paret et al. (2017)
								X				Pinto et al. (2014)
										X		Pulcu et al. (2014)
									X			Zhang et al. (2015)

Note: ADHD attention deficit hyperactivity disorder, *EF* executive functions, *CEF* cold executive functions, *HEF* hot executive functions, *PD* personality disorder and bottom-up processing. They entail processes engaged in delay aversion, affective/risky decision-making, and social cognition (emotion recognition and Theory of Mind) among others (Chan et al., 2018; McDonald, 2013; Salehinejad et al., 2021). Cold and hot EFs interact in a dynamic way to process the information required to solve problems (Cunningham & Zelazo, 2007). This reflects the prevailing view that both are forms of deliberate, effortful, and self-regulatory processing that is supported by networks of the prefrontal cortex (PFC) (Zelazo et al., 2016). It is well established that given the protracted maturation of PFC regions, EFs are among the last cognitive functions to reach maturity (Kolk & Rakic, 2022). Thus, through a pattern of continuous improvement and refinement, it seems that hot EFs develop relatively slower than cold EFs (e.g., Prencipe et al., 2011). In adulthood, stable enhancements in cognitive flexibility, working memory, strategic planning, inhibitory control, affective decision-making, and reward-related behaviors are observed (De Luca & Leventer, 2008; Ferguson et al., 2021; Richards et al., 2013).

A large scale of fronto-striato parietal and frontocerebellar networks are involved in the modulation of executive functioning (Koziol et al., 2013; Rubia, 2018). In particular, dorsolateral prefrontal circuits mediate control of cold aspects of EFs while the orbitofrontal cortex (OFC) mediates control of hot features of EFs (Ward, 2020; Zelazo & Müller, 2002).

ADHD symptoms in adults have been linked to difficulties in the cognitive processes needed for goal-direction behaviors, known as EFs (Rubia, 2018). These abilities are closely related to daily-life functioning outcomes in several areas such as academic achievement (Dorr & Armstrong, 2019), occupational and social functioning, and quality of life (Holst & Thorell, 2020; Sjöwall & Thorell, 2022).

Although there is a paucity of studies examining cognitive functioning in adults with ADHD, such studies are increasing, mainly with regard to executive functioning. The evidence suggests significant EF impairment in adults with ADHD, with considerably heterogeneous deficit patterns. This makes it difficult to clearly identify any single domain of neurocognitive specific deficit (Coghill et al., 2018; Dowson & Blakwell, 2011; Salehinejad et al., 2021; Sjöwall & Thorell, 2022). In addition, despite some evidence revealing more prominent deficits in working memory and inhibitory control in women than in men (e.g., Stibbe et al., 2020), results on EF differences by gender in adults with ADHD remain inconclusive (e.g., Chen et al., 2021; Williamson & Johnston, 2015).

Cold EF impairments in adults with ADHD include disturbances in working memory (Salehinejad et al., 2021; Skodzik et al., 2017), cognitive flexibility or set shifting (Barone et al., 2012; Salehinejad et al., 2021), inhibition (Coghill et al., 2018; Miller et al., 2012), and strategic planning (Fuermaier et al., 2013; Thorell et al., 2017). There is a mounting evidence that ADHD in adults is associated with hot EF impairments in temporal discounting/delay discounting (Asherson et al., 2018; Petrovic & Castellanos, 2016), delay aversion (Holst & Thorell, 2017; Thorell et al., 2017), decision-making and risk-taking behavior (Asherson et al., 2018; Buelow, 2020; Dekkers et al., 2021), and reward responsiveness (Buelow, 2020; Mowinckel et al., 2015). The disturbances in hot and cold EF tend to persist into adulthood and are characterized by a more diverse set of domains of impairment than in children (Adler et al., 2017; Franke et al., 2018; Miller et al., 2012). Indeed, some adults with ADHD have one or several domains affected, or simply do not show any kind of deficits (Asherson et al., 2018;). Although both types of executive domains (cold and hot) influence each other (Petrovic & Castellanos, 2016), performance deficit profiles in each domain are relatively independent of each other (Asherson et al., 2018; Buelow, 2020; Coghill et al., 2018). Finally, impairments in young adults with ADHD on hot EF measures may be larger than those on cold EF measures, probably because they have difficulty making reflective advantageous decisions (e.g., more suboptimal decision-making) in situations with strong motivational demands that more closely resemble decision-making in daily life

(Dekkers et al., 2021; Prencipe et al., 2011). Additionally, a recent meta-analysis shows that real-life decision-making deficits related to ADHD are underlain by suboptimal decision-making and not risk-seeking (Dekkers et al., 2021).

Regarding the relationships between ADHD presentation and cold and hot EF deficits, study results have provided inconsistent findings (LeRoy et al., 2018; Mostert et al., 2015; Schulze et al., 2021). In particular, some studies in adults show that working memory, inhibition, and flexibility are closely related to the predominantly inattentive presentation of ADHD (e.g., Adler et al., 2017; Arabacı & Parris, 2020), while delay discounting, decision-making, and emotion dyscontrol are more characteristics of combined and hyperactive/impulsive presentations (Adler et al., 2017; Schulze et al., 2021). Other studies have found support for working memory deficits linked to inattentive and hyperactive ADHD symptoms (e.g., Brydges et al., 2021), delay discount related to hyperactivity/impulsivity ADHD symptoms (Mostert et al., 2018; Sjöwall & Thorell, 2022), and inhibition deficits for all three ADHD presentations (e.g., Mostert et al., 2018). Other studies have failed to find differences between predominantly inattentive and combined presentation and their impact on planning, inhibition, cognitive flexibility, and risky decision-making measures (Groen et al., 2013; LeRoy et al., 2018). In general, it is unclear to what extent the specific subset of ADHD symptoms, either inattention or hyperactivity/impulsivity, could account for cold or hot EF deficits in ADHD (Buelow, 2020; Thissen et al., 2014). A factor that complicates the distinction between cold and hot EF deficits by ADHD presentation is the presence of some abnormalities in neuroanatomical networks underlying both EF types that may remain fixed or change with age. These may be linked to the clinical characterization and course of the disorder (e.g., Plichta & Scheres, 2014; Shaw & Szekely, 2018). Despite these limitations, and the fact that there is still no agreement on whether executive deficits are the main problem in ADHD or part of a causal pathway, research suggests that ADHD is closely related to an interplay between top-down (controlled responding) and bottom-up (reactive responding) regulatory processes that alter emotion, action, and cognition (Nigg, 2010, 2017).

A key concept underlying executive functioning is that cold and hot EF appear to be grounded in top-down and bottom-up processes that are closely related to the development of self-regulation abilities (Vink et al., 2020). To transition to adulthood, self-regulation is closely related to the personality trait of conscientiousness and self-control, which is defined by the ability to regulate attention, emotion, and behavior (Eisenberg et al., 2014). This overlaps with executive processes of delay of gratification and inhibitory control (Duckworth & Kern, 2011). Conscientiousness is associated with effortful and reactive control and has its origins in the early development of the regulatory dimension of temperament: effortful control (EC) (e.g., Eisenberg et al., 2014; Nigg, 2006; Roberts et al., 2014). EC has been defined as “the efficiency of executive attention, including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and to detect errors” (Rothbart & Bates, 2006, p. 126). EC and later adult conscientiousness development show some relative continuity in the increase from adolescence to adulthood (e.g., Atherton et al., 2020; Eisenberg et al., 2014). This could mean that weak development of EC predisposes the presence of ADHD symptoms. Thus, the risk of secondary problems in executive control development increases, with a residual effect in adulthood, which accounts for the relationship between decreased conscientiousness and adverse executive outcomes (e.g., Atherton et al., 2020; Nigg et al., 2002). Evidence suggests relationships between hot and cold EF, ADHD, and self-regulatory traits (effortful control/conscientiousness) in young adults and adults (Jacobsson et al., 2021; Johann & Karbach, 2021). This conceptual and empirical overlap may suggest that the persistence of executive deficits in ADHD in adulthood may be the result of a complex interplay between ADHD symptoms and temperamental and personality vulnerabilities (e.g., Nigg, 2006).

5.4 Emotional Dysregulation and ADHD

There is a growing understanding that within the symptoms that are most characteristics of ADHD are those related to difficulties in the emotional domain (Beheshti et al., 2020; Shaw et al., 2014; Viering et al., 2021). Indeed, many of the emotional challenges that face adults with ADHD include persistent symptoms of anger or irritability, feeling hassled, emotional lability or impulsivity, acute mood swings, feeling overwhelmed, and distress intolerance (Christiansen et al., 2019; Faraone et al., 2018; Hirsch et al., 2019). Together, these emotional features show that there may be a lot of heterogeneity in the range of symptoms of emotional dysregulation (ED) among adults with ADHD (Faraone et al., 2018). ED in individuals with ADHD is characterized by intense, unstable emotional reactions; irritability and hot-temper outbursts; and emotional over-reactivity (Ryckaert et al., 2018). Studies highlight the high frequency of individuals with ADHD who struggle to regulate their own emotions (Skirrow et al., 2009), with an estimated prevalence of 34–72% of adults with ADHD suffering significant symptoms of emotional dysregulation (Reimherr et al., 2010; Shaw et al., 2014). For instance, Beheshti and colleagues (2020) reported on this in their meta-analysis of significant and positive correlations between ED and severity of ADHD symptoms ($r = 0.54$). In addition, the clinical course of ADHD symptoms from childhood to adulthood is closely related to abnormalities in neural networks that mediate attention control, emotion regulation, and the processing of reward (Shaw et al., 2015). Besides, studies have found that gender plays a significant role in the association between difficulties in emotion regulation and ADHD, with a higher prevalence of ED in women than in men (Welkie et al., 2021; Young et al., 2020a). Finally, adults with ADHD and ED symptoms frequently struggle with poor outcomes in social adjustment and occupational quality as well as educational achievement in the medium and longterms (Ben-Dor Cohen et al., 2021; Qian et al., 2016; Sjöwall & Thorell, 2022; Surman et al., 2013a).

Regarding ADHD symptoms, some studies have shown that ED varies substantially in ADHD groups and contributes considerably to the severity of ADHD symptoms (Corbisiero et al., 2013). In this regard, previous research has emphasized that emotion regulation deficits seem to be more frequent in adults with ADHD combined presentation than with inattentive presentation (Reimherr et al., 2010; Retz et al., 2012). Interestingly, recent data analyzing two ADHD groups (i.e., ADHD inattentive [ADHD-I] and ADHD with emotional dysregulation [ADHD-ED]) showed that although both groups had inattention and disorganization symptoms, only 58% of adults with ADHD-I had marked emotional symptoms compared to 78% of adults with ADHD-ED (Reimherr et al., 2020).

From a theoretical perspective, there is no single universal definition of emotion dysregulation. However, Shaw et al. conceptualize ED as “an individual’s inability to modify an emotional state so as to promote adaptive, goal-oriented behaviors” (Shaw et al., 2014, p. 127). ED is a multidimensional construct that involves a lack of inhibition related to strong emotional reactions and the failure to engage in self-regulatory actions such as, for instance, adequate and further refocusing of attention (Mitchell et al., 2012). Thus, individuals with ADHD could experience poor cognitive inhibitory control of emotional reactions, especially those of a negative type (e.g., frustration and anger). This would lead to significant emotional impulsiveness, which has been regarded as a central aspect of ADHD (Barkley, 2010; Mitchell et al., 2012).

The relevance of ED in the clinical picture of adults with ADHD has been addressed by three conceptual models, discussed in the review by Shaw et al. (2014). The first model conceptualizes emotion dysregulation as an integral part of ADHD rather than related symptoms, where executive control (i.e., inhibition and working memory) deficits underpin ADHD symptoms and emotional dysregulation (Barkley, 2018). The second model theorizes that ADHD with deficient emotional regulation is a distinct entity or subtype/presentation of ADHD, with distinguishable and separate neurocognitive deficits (Surman et al., 2011). Finally, the third model states that, although symptoms of ADHD and emotional dysregulation are correlated, they are independent dimensions, each with overlapping but dissociable neurocognitive impairments (Hirsch et al., 2019; Surman et al., 2011).

5.5 Additive Effect of Executive Function Deficits and Emotion Dysregulation in ADHD

In a major review, Faraone et al. (2018) suggested that difficulties with emotionality and symptoms of ED are among the key characteristics associated with ADHD and are much like executive functioning deficits, given their high prevalence. In this regard, integrated models of ADHD suggest that interactions between emotional (bottom-up regulation) and executive control (top-down modulation) processes are core components to understand some behavioral outcomes for individuals with ADHD (Matthews et al., 2014; Nigg & Casey, 2005). This aspect is relevant, since there is cumulative evidence that poor functional connectivity in cortical regions at the interface of cognition and emotion, most prominently the medial and ventrolateral prefrontal cortex networks are related to ADHD symptoms and ED (Rubia, 2018; Shaw et al., 2014). ED symptoms could be caused by widespread brain dysfunctions in amygdala, ventral striatum, and orbito-frontal regions involved in bottom-up emotion generation/processing (Rubia, 2018; Shaw et al., 2014). Additionally, significantly decreased functional connectivity between the amygdala and PFC (top-down emotional regulation associated with executive networks) could be linked to poor emotional outcomes in ADHD (Christiansen et al., 2019; Viering et al., 2021). For instance, in young adults with ADHD, amygdala activation and functional connections with medial prefrontal structures may be related to emotion recognition and categorization, assessed by neuropsychological tasks such as the emotional face-matching task (Viering et al., 2021). Similarly, significant relationships have been found between trait anger subscales and shifting attention measures and between trait anger control subscales of the State Trait Anger Expression Inventory (STAXI; Spielberger, 1988) and inhibition measures (McDonagh et al., 2019). In addition, poor self-concept outcomes in adults with ADHD are probably cumulating sequels of cognitive deficits, which are at least partially driven by ineffective long-term regulation of emotions (Hirsch et al., 2018). Collectively, these findings suggest that abnormal activity at the cortical nexus between emotion and cognition may underlie difficulties in attentional allocation of emotional stimuli, which may lead to impaired emotion regulation outcomes (Shaw et al., 2014). Other theoretical frameworks of ADHD posit that ED is just another expression of deficits in some prominent executive functions such as behavioral inhibition (Barkley, 2010). Moreover, Surman et al. (2013b) analyzed whether executive deficits accounted for the relationship between deficient emotional self-regulation and ADHD symptoms in a sample of adults with ADHD. They did not find that performance on neuropsychological tests differentiated ADHD adults with and without ED problems. Therefore, they concluded that executive dysfunction is probably not a major contributor to the manifestation of emotional difficulties in ADHD (Surman et al., 2013b).

However, it is important to note that symptoms of ED are a salient feature of other psychiatric disorders that co-occur with ADHD in young adults and adults (Faraone et al., 2018) (see Table 5.1). Indeed, there is evidence that ED symptoms are present in a wide range of internalizing and externalizing domains (Ryckaert et al., 2018). Studies in adults with ADHD show that emotional regulation problems seem to compromise the severity of ADHD symptoms and comorbid psychiatric conditions and can unfavorably complicate the clinical profile and outcomes of deficits (Corbisiero et al., 2013; Ryckaert et al., 2018). For instance, symptoms of excessive emotional instability, irritability, or mood instability in adults with ADHD might mimic others psychiatric conditions such as anxiety or bipolar disorders (Asherson et al., 2016). This is interesting, since Petrovic and

Castellanos (2016) suggest that emotional groups of ADHD may be located at an intermediate level in a gradient of top-down control extending from non-emotional "cold" executive control to more emotional "hot" executive control. Thus, emotional instability disorders (e.g., bipolar and antisocial personality disorders) that, like ADHD, are characterized by dysfunctional top-down regulation of information processing may lie along with ADHD mainly at the emotional side of the gradient (Petrovic & Castellanos, 2016). However, as Faraone et al. (2018) suggest, given that emotional symptoms are part of many comorbid conditions with ADHD, it is likely that ED symptoms in ADHD are a type of epiphenomenal comorbidity. Importantly, ED symptoms appear not to be specific to ADHD or to any other psychiatric disorders (Ryckaert et al., 2018). Furthermore, Skirrow and Asherson (2013) reported in a sample of ADHD adults, links between ADHD symptoms and emotional instability, independently of comorbid condition symptoms.

Collectively, these findings provide valuable insights that emotion regulation impairments seem to be a key feature of the clinical picture of ADHD. However, alone they cannot thoroughly account for or define ADHD (e.g., Christiansen et al., 2019; Corbisiero et al., 2013). The link between ADHD symptoms and ED appears to be partially independent of psychiatric comorbid conditions that co-occur with ADHD (Surman et al., 2013a). Additionally, emotion regulation and executive function impairments are likely to be related, but they do not completely overlap in terms of ADHD symptom dimensions (Sjöwall & Thorell, 2022).

5.6 Assessment and Treatment of ADHD and Related Difficulties in EF and ED

The diagnosis of ADHD in adults is very challenging, given the heterogeneity that characterizes the profile of executive deficits (Nigg, 2017) and emotion dysregulation symptoms (Faraone et al., 2018). Added to this is the fact that, as mentioned above, hot and cold EF impairments and symptoms, associated with emotional regulation problems, are present across many disorders, with different clinical characteristics (Baskin-Sommers et al., 2022; Hirsch et al., 2019; Petrovic & Castellanos, 2016; Zhang et al., 2021).

The diagnosis of ADHD in adults is based on a clinical approach, given that there are no objective measures or laboratory-based tests that can determine it (Haavik et al., 2010). Several authors state that the best assessment practices to improve diagnostic truthfulness and reduce the probability of misdiagnosis in ADHD involve several sources of information (self- and hetero-informant rating) and methods (interviews, behavior rating scales, questionnaires, etc.) (Haavik et al., 2010; Marshall et al., 2019; Ramsay, 2017).

Regarding the assessment of executive functioning, several studies in samples of adults screened for ADHD have found that EF measures discriminate well between ADHD and non-ADHD participants (Brown, 2013; Kessler et al., 2010; Nikolas et al., 2019). Thus, given the implications of executive functioning in the symptom picture of adults with ADHD, the use of performance-based measures together with behavior rating scales may help to obtain a more reliable profile of executive deficits (Marshall et al., 2019). In particular, the use of different approaches that reliably cover cognitive (cold and hot) and behavioral EF should be considered.

During early adulthood, regional patterns of structure–function coupling that support age-related enhancement in executive functioning continue to develop (Baum et al., 2020). Thus, executive functioning assessment implies considering EF in the context of other cognitive functions and the selection of measures that can isolate or at least identify the specific components of EF that are expected to be measured (Anderson et al., 2008). In particular, EF assessment can be built on the administration of different tasks, each focused on examining specific aspects of a particular function, and subsequently ruling out abilities and skills that are intact or deficient (Anderson et al., 2008). Two kinds of measures are used to assess cognitive and behavioral aspects of executive functioning: performance-based measures and behavioral-rating scales. These two types of measures assess different aspects of executive functioning and therefore cannot be considered equivalent or interchangeable. Instead, they are complementary (Toplak et al., 2017).

5.6.1 Cognitive EF Assessment: Cold and Hot Neuropsychological Measures

These measures provide information on executive functioning under highly structured and standardized assessment conditions. The evaluator structures the tasks, provides guidance for performance, and motivates the participant to achieve performance (Meltzer et al., 2018). This procedure informs about executive functioning in optimal assessment situations (Silver, 2014) and provides information on performance indices such as accuracy and response time (Toplak et al., 2017). Cold EF measures involve abstract/decontextualized tasks that have a relatively neutral affective or motivational component (Zelazo et al., 2016; Zelazo & Carlson, 2020). Traditional "cold" neuropsychological measures include tests that assess aspects of EF in adults such as planning, cognitive flexibility or set-shifting, working memory, selective attention and inhibition (see Table 5.2). A group of neuropsychological batteries use multiple tasks to assess domains of executive functioning: the Delis–Kaplan Executive Function System (D-KEFS; Delis et al., 2001a) and the Tasks of Executive Control (TEC; Isquith et al., 2010). Hot EF measures involve tasks with high motivational demand in which individuals show approach or avoidance responses in relation to a real concern of standing to win or lose something (Zelazo et al., 2016; Zelazo & Carlson, 2020). In particular, EF tasks encompass measures that involve decision-making such as gambling tasks with implicit and explicit rules, reward-related behaviors, and delay discounting (see Table 5.3).

In general, although these measures have proven useful in detecting executive functioning problems, they have some limitations (Toplak et al., 2013). Indeed, the structured assessment conditions, the short duration of the tasks, and their high complexity reduce the possibility of generalizing the results to everyday situations of daily life. Another relevant aspect is that cognitive EF measures show only a modest effect size to differentiate between groups. This would suggest that only a small group of adults with ADHD would have EF problems on any specific measure (Marshall et al., 2019). One of the most important limitations is linked to the task impurity problem because it involves different cognitive processes and thus it is difficult to separate executive demands from those that are not (Barkley & Murphy, 2011; Snyder et al., 2015). Notably, one task can tap both hot and cold processes to some extent. Therefore, it is difficult to determine accurately which element of the task should be manipulated most to elicit one process more than the other (Peterson & Welsh, 2014).

5.6.2 Behavioral EF Assessment: Behavioral Rating Scales

EF rating scales were developed to provide an ecologically valid index of executive problem-solving skills in different contexts and everyday life situations (Toplak et al., 2017). This type of measure is based on how various informants rate (self- and hetero-informants' ratings) observable behavior related to EFs that reflects perceived success or difficulties in multiple situations of daily life (Silver, 2014; Toplak et al., 2017). Behavioral inventories may be better than neuropsychological tests at characterizing the type of deficits or EF skills needed to solve specific problems in different life contexts (Barkley & Murphy, 2011; Toplak et al., 2017). This information has practical value. More than providing information on EF skills per se, it indicates how the individual uses EF to accomplish goals in daily situations that are not under control (Silver, 2014). Despite the valuable information provided by these rating scales, there are very few available for behavioral EF assessment in adults with ADHD. The most commonly applied measures of behavioral EF in adults are Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011), the behavior rating inventory of executive functions, second edition (BRIEF-2; Gioia et al., 2015), and Brown Attention-Deficit Disorder Scales (BADDS, Brown, 1996). There are two recent EF rating scales available for adults: the Comprehensive Executive Function Inventory (CEFI adult; Naglieri & Goldstein, 2017) and the Delis Rating of Executive Function (D-REF adult; Delis, 2021). However, to the best of our knowledge, no studies using these measures in samples of adults with ADHD exist to date (see Table 5.4).

Some disadvantages of behavioral EF rating scales concern several types of response biases, such as informants' expectations and their conception of which behaviors are adaptive or not in the context, or their difficulty in clearly defining behavior over time (Merrell, 2008), the specificity of the behavioral situation and the subjective characteristics of the information obtained from the informants (Merrell, 2008).

Notably, in adults, findings on hot EF are scarce, especially regarding assessment instruments compared to cold EF measures. Therefore, there is less evidence of their utility and effectiveness in detecting executive deficits (e.g., Poon, 2018). Furthermore, EF behavior rating scales are reliable predictors of symptoms related to DSM ADHD criteria diagnosis (Marshall et al., 2019). Finally, as some authors point out, given that performance results of neuropsychological tasks often differ from those obtained in EF rating scales and that a cognitive task probably involves top-down and bottom-up processing, more research is necessary to improve decision-making regarding reliable measures to assess executive functioning among adults with ADHD (e.g., Lovett & Harrison, 2021).

5.7 Assessment of Emotional Dysregulation Symptoms

Although most emotional regulation measures are not specifically developed for ADHD (Faraone et al., 2018), recent research in adults with ADHD has reported the use of rating scales and interview measures as a useful strategy to capture the clinical features of ED symptoms (Ryckaert et al., 2018). Specifically, some self-administered questionnaires are available with rating versions to be completed by other informants (i.e., parent, adult sibling, or intimate partner) and clinician ratings (see Table 5.5) (Beheshti et al., 2020; Ryckaert et al., 2018). The most widely used rating scales to assess emotional processes and related concepts are the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004), the Affective Lability Scale-Short Form (ALS-18; Oliver & Simons, 2004), and the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Here, it is important to highlight that some scales used to assess ADHD symptoms such as the Conners' Adult Attention-Deficit Rating Scale (CAARS; Conners et al., 1999) and the Wender-Reimherr Adult Attention Deficit Disorder Scale (WRAADDS; Marchant et al., 2013) also include subscales that assess symptoms related to emotional regulation problems (Faraone et al., 2018) (see Table 5.5). In this sense and as shown in Table 5.5, rating scales that assess EF like the Behavior Rating Inventory of Executive Function (BRIEF-A; Roth et al., 2005) and Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011) also include subscales that assess emotional dysregulation.

In addition, some clinical-rated interviews forms such as the WRAADDS (Marchant et al., 2013) are available (Ryckaert et al., 2018). Some studies show that assessment approaches such as the speech analysis of language or experience sampling methods help to understand the emotion regulation problems in ADHD adults, since they allow changes to be captured at the level of everyday emotional experience (Ryckaert et al., 2018).

Thus, consideration of the assessment of emotional dysregulation symptoms in EF and ADHD measures reflects a broader conceptualization of ADHD that encompasses executive functioning and emotional regulation processes that can explain to some extent certain regulation impairments linked to ADHD (e.g., Faraone et al., 2018; Retz et al., 2012). In addition, the

Table 5.2 Examples of common cold EF measures for the assessment of adults with ADHD

Cold EF	Performance-based measures Measures	Study
Working memory	Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987)	Hida et al. (2020)
	Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977)	Lundervold et al. (2015)
	California Verbal Learning Test (CVLT-II; Delis et al., 2000)	Lundervold et al. (2015)
	The Word Memory Test (WMT; Green, 2003);	Nikolas et al. (2019)
	Rey-Osterrieth complex figure-recall (ROCF; Osterrieth, 1944)	Skodzik et al. (2017)
	Wechsler Adult Intelligence Scale–IV (WAIS-IV, Wechsler, 2008): working memory index (digit span and arithmetic)	Theiling and Petermann (2016)
Inhibition	Oculomotor response measures: Antisaccade task (Hallett, 1978); Memory-guided saccade task (MGSs; Leigh & Zee, 2006); Ocular fixation task (Gould et al., 2001) and visually guided saccades (VGS; Gnadt et al., 1991)	Chamorro et al. (2021)
	Stroop Colour-Word Interference Task (Stroop, 1935)	Fuermaier et al. (2015)
	Matching familiar figures test (MFFT; Kagan, 1965)	Hervey et al. (2004)
	Conners' Continuous Performance Test (CPT-2; Conners, 2000)	MacQueen et al. (2017)
	Simon task (Simon & Small, 1969); Stop signal task (Logan, 1994) and Go/no go task (Band & van Boxtel, 1999)	Sebastian et al. (2012)
Planning	Delayed task execution (Fuermaier et al., 2013)	Butzbach et al. (2019)
	Maze tracing tasks	Dåderman et al. (2012)
	Tower of London-Freiburg Version (TOL-F, Christoph et al., 2011)	Guo et al. (2021)
	Tower of Hanoi task (Pennington et al. 1993)	Hervey et al. (2004)
	Stockings of Cambridge/Cambridge Neuropsychological Test Automated Battery (SOC-CANTAB; Luciana & Nelson, 2000)	Low et al. (2018)
	Tower test/Delis-Kaplan Executive Function System (DKEFS; Delis et al., 2001b)	Nikolas et al. (2019)
Cognitive flexibility	Trail Making Test (TMT; Reitan, 1958)	Butzbach et al. (2019)
	Task-switching paradigms	Dibbets et al. (2010)
	Color Word Interference test/D-KEFS (CWIT; Delis et al., 2001b)	Halleland et al. (2012)
	Wisconsin card sorting test (WCST-64; Greve, 2001)	MacQueen et al. (2017)

Table 5.3 Examples of common hot EF measures for the assessment of adults with ADHD

Hot EF	Measures	Study
Decision-making	Balloon analogue risk task (BART; Lejuez et al., 2002).	Buelow (2020)
	Risky decision-making/Game of dice task (Brand et al., 2005)	Buelow (2020)
	Probability discounting task (PD; Scheres et al., 2006)	Dai et al. (2016)
	Card playing task (CPT; Newman et al., 1992)	Dai et al. (2016)
	Cambridge gambling Task (CGT; Rogers et al., 1999)	Dekkers et al. (2021)
	The monetary delay discounting tasks (e.g., Fassbender et al., 2014)	Jackson and MacKillop (2016)
	The Quick Delay Questionnaire (QDQ; Clare et al., 2010)	Low et al. (2018)
	Iowa gambling task (Bechara et al., 1994)	MacQueen et al. (2017)

Table 5.4 Examples of common behavioral EF measures for the assessment of adults with ADHD

Behavioral EF measures (Rating scales)			
EF	Measures	Informants	Study
Clusters: Organizing/prioritizing and activating to work; focusing/sustaining and shifting attention; regulating alertness/sustaining effort and processing speed; managing frustration and modulating emotions; utilizing working memory and accessing recall	Brown Attention-Deficit Disorder Scales (BADDS; Brown, 1996)	Self-rating	Brown et al. (2022)
Executive functioning in behavioral, cognitive, emotional and motivational domains	Dysexecutive Questionnaire (DEX; Burgess et al., 1998)	Self-rating	Fuermaier et al. (2015)
Memory, attention and EF	Questionnaire on Mental Ability (FLEI; Beblo et al., 2012)	Self-rating	Guo et al. (2021)
Motivational/behavioral drive; Organization; impulse control/self-inhibition; empathy; and strategic planning	Executive Function Index (EFI) (Spinella, 2005)	Self-rating	Mohamed et al. (2021)
Self-organization problem solving; self-management to time; self-regulation of emotion; self-restraint; and self-motivation	Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011).	Self- and other report	Nikolas et al. (2019)
Inhibit, self-monitor, plan/organize, shift, initiate, task monitor, emotional control, working memory and organization	Behavior Rating Inventory of Executive Function (BRIEF-A; Roth et al., 2005).	Self- and other-report	Silverstein et al. (2020)

use of rating scales to assess symptoms of ED can provide valid and reliable evidence of the relevance of this construct in the psychopathology of ADHD (Retz et al., 2012).

To date, there is no one gold-standard tool to assess emotional dysregulation symptoms (Faraone et al., 2018). Their evaluation in the ADHD context is quite a difficult task due to the complex and dynamic nature of emotional expression (e.g., Ryckaert et al., 2018). Added to this is the diversity of terms used to represent emotional symptoms related to ADHD (Faraone et al., 2018). Regarding this last point, most rating scales focus more on the notion of self-regulation than on other emotional processes, such as reactive response style or emotional lability, which is considered to be closely related to ED patterns (Faraone et al., 2018). In addition, many psychological disorders (e.g., bipolar disorders) co-occurring with ADHD may manifest some underlying emotional regulation impairments that are quite similar to ADHD (e.g., Gross & Jazaieri, 2014) (See Table 5.1). Despite this, ED can be considered a transdiagnostic construct of importance in disorders such as ADHD and bipolar disorders rather than specific to any of them (Kebets et al., 2021). Therefore, its inclusion in the ADHD assessment protocol is essential.

5.8 Treatment

Most treatment studies of adults with ADHD typically last a few weeks and have as primary outcome changes in ADHD symptoms. The treatment goal for ADHD should be not only temporary symptom relief but also the establishment of a more favorable long-term developmental trajectory.

Pharmacological interventions have abundant empirical support for their effectiveness in adults with ADHD who have either moderate or severe impairment (National Institute for Health and Care Excellence, 2018). Some authors consider stimulant medications as the first-line treatment for ADHD (Seixas et al., 2012), but little is known about their effects on long-term outcome, including symptom levels, occupational performance, adaptative functioning, or quality of life. However, many adults with ADHD cannot, or will not, take medication. Others show a poor or partial response (Lofthouse et al., 2012; Wilens

Table 5.5 Common rating scales used for the assessment of emotional symptoms in adults with ADHD

Rating scales	Informants	Study
Conners' Adult Attention-Deficit Rating Scale (CAARS; Conners et al., 1999) (Impulsivity/emotional lability subscale)	Self-rating	Beheshti et al. (2020)
Wender-Reimherr Adult Attention Deficit Disorder Scale (SR-WRAADDS; Marchant et al., 2015)	Self-rating	Ben-Dor Cohen et al. (2021)
Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004)	Self-rating	Ben-Dor Cohen et al. (2021)
Wender Utah Rating Scale (WURS; Ward et al., 1993)	Self-rating	Brevik et al. (2020)
Brown attention-deficit disorder scales (BADDS; Brown, 1996) (Managing frustration and modulating emotions subscales)	Self-rating	Corbisiero et al. (2013)
Emotion Dysregulation Scale, short version (EDS-Short; Powers et al., 2015)	Self-rating	Faraone et al. (2018)
State Difficulties in Emotion Regulation Scale (SDERS; Lavender et al., 2017)	Self-rating	Faraone et al. (2018)
Emotion Regulation Skills Questionnaire (ERSQ; Berking & Znoj, 2008)	Self-rating	Hirsch et al. (2018)
Emotion Regulation Questionnaire (ERQ; Gross & John, 2003)	Self-rating	Materna et al. (2019)
Distress Tolerance Scale (DTS; Simons & Gaher, 2005)	Self-rating	Mitchell et al. (2013)
Wender-Reimherr Adult Attention Deficit Disorder Scale (WRAADDS; Marchant et al., 2013) (Emotional dysregulation subscale)	Interviewer-administered scale	Reimherr et al. (2020)
Emotional Impulsiveness Scale (EIS; Barkley & Fischer, 2010)	Self- and other-rating	Ryckaert et al. (2018)
Behavior Rating Inventory of Executive Function (BRIEF-A; Roth et al., 2005) (Emotion control subscale)	Self- and other-rating	Silverstein et al. (2020)
Comprehensive Emotion Regulation Inventory (CERI; Thorell et al., 2019)	Self-rating	Sjöwall and Thorell (2022)
Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011) (Self-regulation of emotion subscale)	Self-rating	Vélez-Pastrana et al. (2016)
Affective Lability Scale – Short Form (ALS-18; Oliver & Simons, 2004) (Aggression subscale)	Self-rating	Weibel et al. (2019)

et al., 2002). In addition, pharmacological treatment is often associated with adverse effects and a high dropout rate (Cunill et al., 2016).

Psychosocial interventions, such as cognitive-behavioral therapy (CBT), are established treatments for ADHD. These approaches help those who cannot tolerate medications, fail to respond to them, or refuse to try. Moreover, a combination of psychosocial and pharmacological treatment has proven more effective than medication alone (Emilsson et al., 2011; Safren et al., 2005; Young et al., 2015) and is associated with improved treatment adherence (Cunill et al., 2016).

Tables 5.6 and 5.7 present a summary of systematic reviews and meta-analyses published since 2012 on the effectiveness of pharmacological and psychosocial treatments for adults with ADHD. As can be seen in these tables, most studies have changes in ADHD symptoms as primary treatment outcomes. Few studies include measures of executive functioning (EF), adjustment or functioning in different areas, and activities of daily living. Some studies include, as secondary outcomes, measures of psychosocial functioning, anxiety or depressive symptoms, and quality of life, among others.

5.8.1 Executive Functioning

A meta-analysis by Poissant et al. (2020) presents nine studies that examine the efficacy of mindfulness-based interventions (MBI) or dialectical behavioral therapy (DBT) and medication approaches in improving EF and emotional regulation. Of these studies, two have as their primary outcomes behavioral EF assessed by self-report rating scales (Hepark et al., 2019; Janssen et al., 2019), two (Fleming et al., 2015; Mitchell et al., 2017) behavioral and cognitive EF, and four (Bueno et al., 2015; Gu et al., 2018; Hesslinger et al., 2002; Zylowska et al., 2008) only cognitive EF. The study by Edel et al. (2017) does not assess EF but skills related to mindfulness and self-efficacy.

Hepark et al. (2019) and Janssen et al. (2019) assessed behavioral EF by the Rating Inventory of Executive Function-Adult Version (BRIEF-A, Roth et al., 2005). Janssen et al. (2019) found no effects of treatment on executive functioning and general functioning. Hepark et al. (2019) found that the treatment group improved significantly in executive functioning with effect sizes varying from moderate to large (Cohen's d between 0.43 and 0.93).

Fleming et al. (2015) assessed behavioral EF with Brown ADD Rating Scales (BADDS) and neuropsychological performance with the Conner's Continuous Performance Test (CPT-2, Conners, 2000). Participants who received DBT showed greater EF improvement than those who received skills training, both at post-treatment ($d = 0.94$) and at follow-up ($d = 0.81$). Mitchell et al. (2017) assessed behavioral and cognitive EF and ED. Behavioral EFs were assessed by self-rating scales (Deficits in Executive Functioning Scale, DEFS; Barkley, 2011 and Behavior Rating Inventory of Executive Functioning-Adult Version, BRIEF-A; Roth et al., 2005). Cognitive EF (selective and continuous attention, inhibition, working memory, and set shifting) was assessed by several cognitive tasks, and emotion dysregulation was assessed by the Difficulties in Emotion Regulation Scale, DERS (Gratz & Roemer, 2004), and the Distress Tolerance Scale, DTS (Simons & Gaher, 2005). The treatment group improved significantly relative to the waiting list group in self- and clinician-rated behavioral EF. Effect sizes were large (d between 1.45 and 2.67). There were non-significant differences in cognitive EF tasks. For ED, there were significant differences between the treatment group and the waiting list group with large ES (d between 1.27 and 1.63).

Bueno et al. (2015) assessed attention using the Attentional Network Test (ANT; Fan et al., 2002) and the Conners Continuous Performance Test (CPT II, Conners, 2000). After the intervention, the treatment group improved significantly on attention measures ($p < .001$). Gu et al. (2018) assessed neuropsychological performance with the Attentional Network Test (ANT; Fan et al., 2002). Participants who received mindfulness-based cognitive therapy (MBCT) outperformed the control group at post-treatment (ES between 1.02 and 1.23) and at follow-up (ES between 0.19 and 1.29) in alerting and orienting reaction time and orienting error scores. Hesslinger et al. (2002) used several cognitive tasks to assess selective and continuous attention, inhibitory control, working memory, and fluency. They used DBT as treatment and found that the treated group improved significantly in selective attention and inhibitory control. However, no significant differences were found in the domains of working memory and fluency EF. Zylowska et al. (2008) assessed attention using the Attention Network Test (ANT; Fan et al., 2002), attentional set shifting and inhibition using the Stroop task (Golden, 1978) and the Trail Making Test (Reitan, 1979), and working memory using the digit span of the Wechsler scales (Wechsler, 1981). On neurocognitive task performance, significant improvements were found at post-treatment for measures of attentional conflict (ANT conflict and Stroop color-word) and set shifting (Trails A and B), all $p < .01$, but not for measures of working memory.

5.8.2 Emotional Dysregulation

Some authors consider ED and additional core features of ADHD because certain facets of ED (such as temper control, affective lability, emotional over-reactivity, emotional impulsivity, and deficient emotional self-regulation) are associated with at least one subtype of ADHD (Barkley, 2015; Corbisiero et al., 2013; Faraone et al.,

Table 5.6 Meta-analysis and systematic reviews of pharmacological interventions for ADHD in adults

Authors	Study types/design (number studies)	Intervention	Control group	Informants	Outcomes measures and ES
Cunill et al. (2016)	43 studies describing 44 RPCCT	Non-stimulant and stimulant medication: ATX, BUP, dAMP, dMPH, DMI, LDX, MAS, MPH, other MPH formulations and MOD. Additional psychotherapy	Placebo; Placebo + additional psychotherapy	Self; Clinicians	MPH was the stimulant that was most frequently studied (20 studies). ATX was the most frequently studied non-stimulant (12 studies). Additional psychotherapy was provided in 11 studies. Pharmacological treatment was more efficacious than the placebo in reducing ADHD symptom severity (SMD = 0.45; $p < 0.00001$). Stimulants had a larger ES than non-stimulant (Diff SMD = 0.18, $p = 0.017$). Clinician-rated efficacy was higher than patient-rated efficacy of the stimulant (Diff SMD = 0.44, $p < 0.0001$). Discontinuation rate was slightly higher with medication than with placebo (31% vs. 29%; OR = 1.18; $p = 0.003$). No difference in treatment discontinuation was found between pharmacological treatment and placebo amongst studies providing psychotherapy (OR = 0.91; $p = 0.64$). AEs were higher with active medication than with placebo (10.9% vs. 3.5%; OR = 3.08; $p < 0.00001$) Discontinuation due to lack of efficacy was infrequent and was higher with placebo than with the medication (2.9% vs. 5.7%, OR = 0.46, $p < 0.00001$).
		MPH, ATX, LDX, MAS	Placebo		

(continued)

Table 5.6 (continued)

Authors	Study types/design (number studies)	Intervention	Control group	Informants	Outcomes measures and ES
Fredriksen et al. (2013)	33 studies: 5 RCT with a follow-up ≥24 weeks; 10 short-term RCT and an open label extension for a duration ≥24 weeks, and 18 treatment studies with naturalistic longitudinal or cross-sectional designs			Self; Clinicians or investigator ratings	*RCT with a follow-up ≥ 24 weeks* MPH superior to placebo in reducing ADHD symptoms [ES between 0.29 and 0.3; responders between 55% and 62% versus placebo between 37% and 42%; improved CGI and emotional regulation. Comorbid psychopathology (anxiety, depression, anger, hostility, etc.)] were not improved. ATX greater total score reduction on scales that assessed ADHD symptoms that placebo (ES between 0.31 and 0.57). Response rates greater for ATX than for placebo; CGI improved for ATX over placebo (ES 0.45–0.46). No significant changes in anxiety or depression symptoms. *Short-term RCT and an open label extension for a duration ≥ 24 week* MPH improved ADHD symptoms (ES = 2.17); decreased scores on ADHD symptom scales from baseline superior for MPH than placebo; GAF improved (MPH superior to placebo). ATX superior to placebo on improved ADHD symptoms (ES between 0.36 and 0.57). LDX and MAS: ADHD symptoms significantly improved as measured by change from baseline in total scores of ADHD self-reported scales and CGI.

Fredriksen and Peleikis (2016)	16 RCT: with follow-up ≥24 weeks (5); Short-term RCT and open label extension phase (11)	MPH, ATX and amphetamine (AMP)	Placebo	Self-report; Observer reports; Physicians' assessment	*Long-term* MPH superior to placebo in response rates (61–62% versus 37–42%) and reducing emotional symptoms (ES = 0.3) ATX significant reductions on scores of ADHD symptoms (self and investigator; ES = 0.6) *Short-term* MPH superior to placebo in response rates (74–87%) versus (0–21%) and significant reductions in scores of ADHD symptoms (60–63%) and emotional dysregulation (66%) ATX significant improvement on scores of ADHD symptoms (scores decreasing between 30% and 33%, self and investigator); disability improved, 25%
Lenzi et al. (2018)	Double-blinded RCT: 23 (qualitative synthesis), 21 (quantitative synthesis). Duration between 5 and 12 weeks; only one study lasting 24 weeks	13 trials on MPH, 5 on ATX, 3 on LDX, 1 on BUP and 1 (Duloxetine)	Placebo	Self-report; Clinicians' report	Compared to placebo: MPH significantly more effective in reducing emotional dysregulation symptoms (ES = 0.34); LDX (ES = 0.34) and ATX (ES = 0.24)
Moukhtarian et al. (2017)	Nine RCT with study duration between 2 and 24 weeks	MPH (different formulations), LDX, ATX	Placebo	Self-report; Investigator ratings	*Emotional lability* Stimulants had a moderate effect (ES = −0.57) ATX had a small effect (ES = −0.21) *ADHD symptoms* Stimulants had a large effect (ES = −0.98) ATX had a moderate effect (ES = −0.57) Stimulants and ATX had a moderate effect on emotional lability (ES = −0.41) and large effects on ADHD symptoms (ES = −0.8)
			Placebo	Physicians	

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Table 5.6 (continued)

Authors	Study types/design (number studies)	Intervention	Control group	Informants	Outcomes measures and ES
Moriyama et al. (2013)	Eight meta-analyses: 7 medication, 1 Psychotherapy + medication Medication: RCT; or Randomized, placebo, controlled trial; or Randomized, double-blind placebo, controlled trial; or double blind placebo, controlled trial. Psychotherapy: controlled and non-controlled trials	Medication: MPH vs placebo; BUP vs placebo; LDX vs MAS vs dAMP; Stimulants vs non-stimulants (ATX, BUP, dMPH, modafinil, MOD, paroxetine); Short-acting stimulants vs long-acting stimulants. CBT			ADHD symptoms: Stimulants significantly decrease ADHD symptoms on a short-term basis when compared to placebo (ES = 0.67). ESs were 0.9 for MPH, 0.73 for MAS, 0.6 for dAMP and 0.8 for LDX. Physicians' ratings and use of higher doses were associated with larger effect size. ESs of short-acting stimulants (4.32) were larger than long-acting stimulants (1.35). Non-stimulants have a significantly lower ES (0.49) than short-acting stimulants (0.67–0.96) and long-acting stimulants (0.67–0.73). Response rate for BUP and Desipramine was significantly greater than that for placebo. ES for CBT = 0.84; for medication, 0.44.[a]

Note: [a]Includes both controlled and uncontrolled studies with considerable methodological problems. The results should be interpreted with caution
ADHD attention deficit/hyperactivity disorder; *AE* adverse event, *ATX* Atomoxetine; *BUP* Bupropion, *GAF* global assessment of functioning, *CGI* Clinical Global Impressions Scale, *DMI* Desipramine, *dAMP* Dexamphetamine, *dMPH* Dexmethylphenidate, *ES* effect size; *LDX* Llisdexamfetamine, *MAS* mixed amphetamine salts, *MPH* Methylphenidate, *MOD* Modafinil, *ODD* odds ratio, *RCT* randomized controlled trials, *RPCCT* randomized placebo-controlled clinical trials, *SMD* Standard Mean Difference

Table 5.7 Meta-analysis and systematic reviews of psychosocial interventions for ADHD in adults

Authors	Study types/design (number studies)	Setting/type intervention: group (no.), individual (no.)	Intervention	Control group	Informants	Outcomes measures and ES	Conclusions
Auclair et al. (2016)	RCT (12)	Individual (5) Group (7)	CBT; Psychoeducation CBT + medication; DBT; Online CBT; Structured discussion	TAU; Waiting list	Self-report; Clinicians blind raters	*Treatment* vs. *controls* ADHD symptoms (0.95), ADHD hyperactivity/ impulsivity (0.34; 10 month to 1-year follow-up). Anxiety symptoms (0.39; follow-up 3–6 months, NS). Depression symptoms (0.30; follow-up 3–6 months, NS)	Significant reduction in ADHD symptoms (0.95), comorbid anxiety (0.39) and depression (0.30) for the CBT group in comparison with controls. Following the end of treatment, ADHD symptoms continue to improve but not the comorbid conditions.
Cairncross and Miller (2020)	10 studies; 4 adult samples; 6 child/ adolescent samples. Adult samples: Pre-and post (1); Waiting list, pre-and-post (2); Waiting list, pre-and-post follow-up (1).	NS	MBIs	Waitlist	Self; Others	ADHD inattention (between −0.10 and −2.42; self, between −0.96 and −1.89; others, −2.944) ADHD hyperactivity/ impulsivity (between −0.26 and −1.62; self, between −0.26 and −1.91; others, −1.32)	MBIs significantly reduced inattention and hyperactive/impulsive symptoms, irrespective of informant.
Guo et al. (2022)	44 RCT studies (23 children and 21 adults with ADHD). Adults: 21 RCT pre-post	Individual (8), Group (9) and Combined (4)	CBT (13); DBT (1); MBI (3); NFB (2); PsyEd (1); CT (1). Participants of 20 studies out of 21 with medication use	TAU (6), AC (9), WL (6)	Observer ratings; Self-reports	*Post-assessment:* ED (0.21): self-report (0.22), observer rating (NS) Depression (0.39): self-report (0.34), observer rating (1.03) Anxiety (NS): self-report (NS), observer rating (0.54)	*Post-treatment:* CBT: small to moderate effects on ED (0.26), depression (0.42) and anxiety (0.33). MBI: Moderate effect for anxiety (0.75) NFB moderate effect on depression (0.65) Other therapies: no significant effects at both

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Table 5.7 (continued)

Authors	Study types/design (number studies)	Setting/type intervention: group (no.), individual (no.)	Intervention	Control group	Informants	Outcomes measures and ES	Conclusions
							post-treatment and follow-up. *Follow-up*: no significant effects on ED, depression and anxiety for self-rating; for observer rating, moderate to large effects on depression (0.74) and anxiety (0.76); no effects on ED.
Jensen et al. (2016)	RCT (2)	Individual (1) Group (1)	CBT	TAU	Self-report; Blind raters	*Treatment* vs. *controls* *Self-reported:* ADHD symptoms (−1.0); depression symptoms (−1.0); anxiety symptoms (−1.0) *Blind reports:* ADHD symptoms (−0.6); functioning CGI (−1.0); depression symptoms (−0.9); anxiety symptoms (−0.9)	Significant reduction in ADHD and comorbid anxiety and depression symptoms. The two therapeutic interventions included in the meta-analysis were defined as CBT, but they differed substantially in the settings and components of the interventions.
Knouse et al. (2017)	32 studies: 18 controlled trials, 12 open trials and 2 controlled trials only pre-post	NS	CBT (full range of cognitive-behavioral interventions available); CBT + medication; DBT.	Active; Not active	Self-report; Clinicians blind raters	*Treatment* vs. *controls* *Self-report:* total ADHD symptoms (0.65), inattention (0.77), hyperactivity/impulsivity (0.34) *Blind report:* total ADHD symptoms (0.56), functioning (0.47); CGI (0.51). *Pre-* vs. *post-treatment*	Skills-based psychosocial treatments targeting cognitive and behavioral processes had medium-to-large effects on self-reported ADHD symptoms from pre- to post-treatment; ES comparing active, placebo control conditions were smaller

						Self-report: total ADHD symptoms (1.00), inattention (1.16), hyperactivity/impulsivity (0.68); functioning (0.73); executive functioning (0.99) *Blind report:* total ADHD symptoms (1.40), CGI (1.12)	than ES compared with non-active, waiting list or continued medication control groups. Effects of CBT on adult ADHD were comparable for participants on and off medication and for a variety of treatment formats (i.e., group vs. individual).
López-Pinar et al. (2018)	12 studies: RCT (9); Uncontrolled single group pre-test to post-test (3)	Individual; Group; Combined	CBT; CBT + Medication; CBT +DBT; MBCT; BFB	TAU; Waiting list; Active	Self-report; Clinicians blind raters	*Treatment* vs. *controls* *Self-report:* total ADHD symptoms (0.71), inattention (0.64), hyperactivity/impulsivity (0.69); global functioning (0.76) *Blind report:* total ADHD symptoms (0.40); inattention (0.14), hyperactivity/impulsivity (0.28); CGI (0.44) *Pre-* vs. *post-treatment* *Self-report:* total ADHD symptoms (1.09), inattention (1.20), hyperactivity/impulsivity (0.83); global functioning (0.58) *Blind report*: total ADHD symptoms (1.18), inattention (0.91), hyperactivity/impulsivity (0.67); CGI (1.20)	Treatment groups: greater improvement than control in total ADHD symptoms, inattention and hyperactivity/impulsivity and global functioning, self-reported. Blind assessors reported a large ES in within-subject outcomes. Treatment effectiveness, according to the CGI and global functioning were significantly increased when the percentage of medicated participants was greater.

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Table 5.7 (continued)

Authors	Study types/design (number studies)	Setting/type intervention: group (no.), individual (no.)	Intervention	Control group	Informants	Outcomes measures and ES	Conclusions
Mongia and Hechtman (2012)	RCT (7)	Individual (1); Group (6)	CBT + medication; DBT + medication; Metacognitive therapy + medication	Waiting list +medication; Relaxation + educational training + medication; Supportive psychotherapy + medication; Structured discussion + medication; TAU + medication; CBT + placebo	Self-report; Blinded report	CBT groups showed more improvement on outcome measures of ADHD, anxiety and depression symptoms (self- and blinded reports), CGI (blinded report), emotional control and functioning (self-report).	CBT is more effective when combined with medication.
Poissant et al. (2020)	RCT and Non-RCT (11); comparison groups (9), pre-post studies (2)	NS	MBIs. Most participants were receiving medication before and during MBIs, psychostimulants like MPH were the most frequently reported.	NS	Self-reports; Others reports	*Comparisons groups:* ADHD symptoms (−0.59, between −0.01 and −1.69); Depression symptoms (−0.36, between −0.18 and −0.73); Executive functioning objective tasks (0.26, between 0.02 and 0.86) *Pre-poststudies:* ADHD symptoms (−0.56, between −0.46 and −0.74); Depression	MBIs are effective to treat ADHD symptoms in adults. There were a moderate improvement of depressive symptoms and executive functioning following MBIs

						symptoms (−0.65, between −0.34 and −0.68); Executive functioning objective tasks (0.81, between 0.58 and 0.93)	
Young et al. (2020b)	RCT (8)	Group (5); Individual (3)	CBT+ medication	Waiting list + medication; Active control + medication	Self-reports Independent reports	*CBT* versus *waiting list:* ADHD symptoms (0.76, between 0.19 and 1.68) *CBT* versus *active control:* ADHD symptoms (0.43, between −0.12 and 0.56)	CBT was superior to waiting list and active control groups in the reduction of ADHD symptoms immediately post-treatment.

Note: AC active control, *ADHD* attention deficit hyperactivity disorder, *BFB* Biofeedback, *CBT* cognitive behavioral therapy, *CGI* clinical global impression, *CT* cognitive therapy, *DBT* dialectical behavioral therapy, *ES* effect size, *HT* hypnotherapy, *MBIs* mindfulness-based interventions, *MBCT* mindfulness-based cognitive therapy, *NFB* neurofeedback, *NS* not stated, *ns* not significant, *PsyEd* psychoeducation, *RCT* randomized controlled trials, *TAU* treatment as usual, *WL* waiting list

2018; Shaw et al., 2014). Shaw et al. (2012) reviewed studies focusing on self-report data about emotion regulation difficulties in children and adults with ADHD and reported prevalence rates of 34–70% in adults. Adults with ADHD and ED show more severe symptoms of ADHD, higher rates of comorbidity, and worse social and occupational adjustment than adults with ADHD but without ED (Biederman et al., 2012; Corbisiero et al., 2013; Surman et al., 2013a). In a recent paper, Materna et al. (2019) analyzed the patterns of neural activation involved in the use of strategies to regulate emotions (reappraisal, distraction and suppression) in a sample of 67 adults (32 with ADHD and 35 controls) matched by age and gender. They found that there were no significant activation differences in the neural appraisal network between adults with ADHD and controls. Control adults reported higher use of reappraisal strategies, while adults with ADHD engaged more in suppression strategies and estimated their emotional competence more negatively.

Ben-Dor Cohen et al. (2021) analyzed the role of ED in explaining the relationship between ADHD and quality of life in a sample of non-referred young adults (ages 18–33) with ADHD ($n = 63$) and controls ($n = 69$), matched by gender and age. Both quality of life and ED were significantly worse in the ADHD group than in the control group. Higher levels of ED predicted lower levels of quality of life and ED moderated the effect of ADHD symptoms on quality of life for the ADHD group. The medication status of the ADHD group had no significant effect on the level of ADHD symptoms, ED, or quality of life.

A meta-analysis by Guo et al. (2022) presents 21 studies that examine the efficacy of therapies (CBT, 13; DBT, 1; MBI, 3; NFB, 2; PsyEd, 1, and CT, 1) in improving anxiety and depression symptoms and ED. Participants of 20 studies out of 21 were on medication. Eight studies had a change in ED as the primary outcome of the intervention. Changes were assessed at post-treatment (four studies at post-treatment and another four studies at post-treatment and follow-up). The duration of follow-up ranged from 3 to 6 months. All studies used rating scales, self-reports, or observer-reports as measures of changes in ED. The results of the meta-analysis indicate that at post-treatment there were low effects of treatments on ED (mean ES = 0.21; self-report = 0.22; and observed rated as non-significant). However, in the follow-up, there were no significant effects of intervention on ED. In terms of the efficacy of the treatments, CBTs have a small effect on ED (mean ES = 0.26) at post-treatment but the other therapies have no significant effects at post-treatment and follow-up.

A review and meta-analysis by Lenzi et al. (2018) consisted of 23 double-blinded RCT with a duration of between 5 and 24 weeks. Participants of these studies were on methylphenidate, MPH (13); atomoxetine, ATX (5); lisdexamfetamine, LDX (3); Bupropion, BUP (1); and Duloxetine (1). The control groups were on a placebo. BRIEF-A (Roth et al., 2005), CAARS (Conners et al., 1999), BADDS (Brown, 1996) and WRAADDS (Wender, 1995) scales, or selected subscales, were used as measures of change, rated by clinicians or self-rated. Compared to the placebo, the stimulants were significantly more effective at reducing ED symptoms (MPH ES = 0.34; LDX ES = 0.34) than non-stimulant ATX (ES = 0.24).

Moukhtarian et al. (2017) presented the results of the effects of stimulant (MPH with different formulations and LDX) and non-stimulant (ATX) medication versus a placebo in improving symptoms of emotional lability in nine RCTs, with a study duration between 2 and 24 weeks. Stimulants had a moderate effect (ES = −0.57) and ATX had a small effect (ES = −0.21) on emotional lability. The effects of stimulant and non-stimulant medication were greater for ADHD symptoms than for emotional lability in both self-ratings and clinician or investigator ratings.

In summary, most reviews and meta-analyses report changes in ADHD symptoms as primary outcomes of interventions. Some studies report changes in emotional symptoms or executive functioning after intervention as secondary outcomes. These studies are generally of short duration and have cross-sectional designs. In recent years, there has been an increase in the number of studies that analyze the efficacy of pharmacological and psychosocial interventions to improve executive functioning and symptoms of ED. These studies are generally cross-sectional in format and with pre- and post-treatment designs. Some have no follow-up or have follow-ups of only a few weeks' duration. There is a need for randomized, controlled, and longitudinal studies that combine manualized group interventions of proven efficacy (e.g., CBT) with individual intervention sessions adapted to the profile of skills and difficulties of people with ADHD. In addition, the effectiveness of the components (individual and group) must be analyzed to improve executive functioning and ED symptoms, given their influence on personal, family, social and occupational well-being of adults with ADHD.

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6 Cognitive Event-Related Potentials and ADHD Across the Lifespan

Sandra Carvalho and Jorge Leite

6.1 Introduction

Attention-deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that is typically diagnosed during childhood; however, symptoms often persist into adulthood (Adamis et al., 2022; Faraone et al., 2006). ADHD symptoms usually start before the age of 12, are present for at least 6 months, and significantly interfere with daily life activities. In addition, ADHD is characterized by a pattern of marked disorganization, difficulties in completing ongoing tasks, forgetfulness, executive dysfunction, deficits in goal-directed behavior, and difficulties in emotional self-control and motivation (Aboitiz et al., 2014; Schreiber et al., 2014). Adults with ADHD also commonly report feeling of inner restlessness, difficulties in directing and sustaining attention toward relevant stimuli while filtering (or ignoring) irrelevant stimuli, as well as increased levels of impulsiveness (Hasler et al., 2016).

Neuroimaging studies have suggested the involvement of multiple brain regions and networks in the pathophysiology of ADHD. Deficits in goal-directed behavior have been linked to activity reduction over the frontostriatal network, as well as reduced volumetry of both anterior cingulate gyrus and dorsolateral prefrontal cortex, which have been linked to cognitive deficits (Magnus et al., 2023). In addition, there is also evidence of abnormal development in the frontal regions (smaller anterior right frontal lobe) (Vaidya, 2012), reduced communication between hemispheres associated with a decreased volume of the corpus callosum (Luders et al., 2009), and decreased volume of the caudate nucleus (O'Dwyer et al., 2016).

Several studies have confirmed that individuals with ADHD have impaired performances in neuropsychological tasks, especially those measuring executive functions, although the sensitivity and specificity of these impairments seem to be rather moderate (Willcutt et al., 2005). Performance in neuropsychological tasks is an indirect way of accessing brain function/dysfunction, and when combined with electrophysiological measures, it provides reliable ways of measuring the interface between the brain and behavior. Therefore, numerous cognitive tasks have been administered while registering electroencephalographic data. The standard Go/NoGo task: visual continuous performance test (VCPT) is one of the most used to evaluate executive functions, namely sustained attention

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and inhibitory control, which have been thought to be impaired in people with ADHD (Müller et al., 2020).

Despite these functional and structural brain changes, there is also growing evidence on the usefulness of electrophysiological markers (i.e., ERPs) in combination with neuropsychological tasks in ADHD across lifespan. Therefore, this chapter presents a summary of the use of cognitive ERPs in the assessment of cognitive (dys)-function in people with ADHD across lifespan.

In the following section, a brief introduction to ERPS will be made, followed by a description of several ERPs and their usefulness as putative biomarkers for cognition.

6.2 Event-Related Potentials (ERPs)

ERPs are electrical brain fluctuations, which are time-locked to a specific stimulus (see Fig. 6.1). ERPs mostly represent postsynaptic potentials and are obtained from the averaged EEG signal within a specific time window (or epoch) after the presentation of an event of interest (for instance, a sound, image), task onsets or motor actions. Typically, the event is repeated multiple times, and by averaging the EEG signal based on the epochs, it is possible to isolate the ERPs. However, in order to interpret the changes in the ERPs voltages, it is also necessary to compare with other brain signals, such as the ones from a prestimulus baseline or a control condition. These voltage differences between two or more conditions provide information on the transient cortical brain dynamics (Fig. 6.1).

Since the activity of each neuron is brief, weak, and noncoincident, and the neuronal tissue provides poor conductance and therefore works as a low-pass filter, EEG (or ERPs) do not allow us to record the electrical activity of a single neuron. ERPs represent instead the summed activity of a large number of synchronous neurons with electric fields oriented in a certain way, which is captured and recorded through the scalp. In this way, ERPs arise in groups of synchronous and parallel activated neurons aligned with each other or by forming another "open field" configuration (e.g., thalamus and cerebellum). Thus, ERP waveforms represent the summation of inhibitory and excitatory postsynaptic potentials of neurons in a network firing in synchrony with cortical neurons and nuclei of subcortical neurons (Babiloni et al., 2020).

In order to record ERPs, these postsynaptic potentials need to be amplified, and only then ERPs can be analyzed by their frequency and voltage differences as a function of time. The different components extracted from the EEG (i.e., ERPs) can be considered exogenous potentials (mandatory responses determined by the physical characteristics of stimuli coming from the outside) and endogenous potentials (manifestations of information processing that may or may not be evoked by the eliciting event or stimulus). Thus, by using EEG and time-locking it to specific stimuli, it is possible to extract ERPs that represent brain processes with a resolution of a few milliseconds (ms). The spatial resolution of this methodology is limited; however, multichannel recordings and different algorithms (e.g., LORETA) allow us to make estimates of the intracerebral sites, where neuronal processes may be taking place. ERPs offer several advantages both as diagnostic tools and to assess specific cognitive dysfunctions, such as (1) noninvasiveness; (2) functional relevance – measurement of neural activity; (3) high time-resolution (behaviors and psychological processes can potentially be monitored on a millisecond-by-millisecond basis); (4) cheap; (5) on-site; (6) portability of new EEG devices; (7) associated to non to mild, transient side effects; (8) ease of administration; and (9) relatively good temporal resolution (with high-density EEG) (Lenartowicz & Loo, 2014).

Cognitive evoked potential (CEP) is a category in which long latency ERPs are obtained. These CEPs are also called endogenous potentials or event-related potentials and are shaped by the motivation, attention, and previous experiences of each subject (Fig. 6.1).

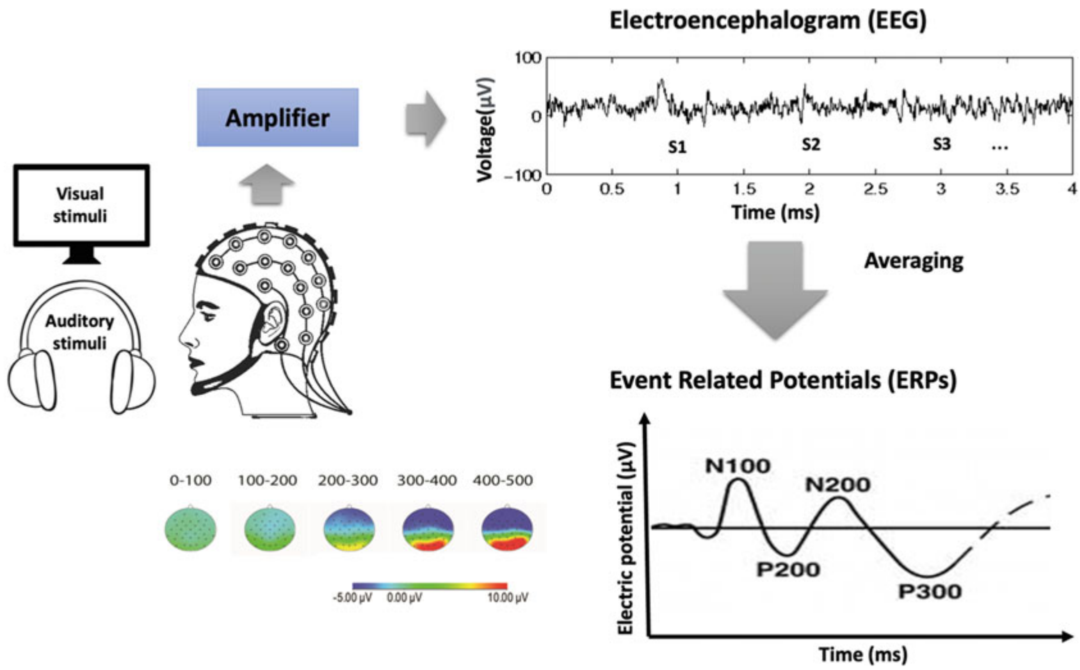

Fig. 6.1 A schematic representation of ERP setting as a task-based methodology elicited by visual or auditory stimuli collected from the raw EEG signal. (Adapted from Hasting (2008))

6.3 ERPs as Putative Neurophysiological Markers for ADHD

A biomarker is defined through the U.S. Food and Drug Administration (FDA) Biomarkers, EndpointS and other Tools (BEST) as

> A defined characteristic that is measured as an indicator of normal biological processes, pathogenic processes, or biological responses to an exposure or intervention, including therapeutic interventions. Biomarkers may include molecular, histologic, radiographic, or physiologic characteristics. A biomarker is not a measure of how an individual feels, functions, or survives (Group, 2016; Validation. 2017 Nov 14 [Updated 2020 Nov 16].)

The term "biomarker" refers to specific indicators in the body such as biological molecules found in the blood or other fluids or tissues in the body, and that can provide information regarding normal or abnormal processes in a specific condition. According to the 2012 consensus report of the World Federation of ADHD (Thome et al., 2012), in order to be considered a biomarker for ADHD, the biomarker needs: (1) to be measured objectively; (2) to be reliably reproduced; (3) to be affordable, easy to conduct and noninvasive; (4) to be potentially used to promote early and accurate diagnosis with a sensitivity >80%; (5) must have a diagnostic specificity >80% for distinguish ADHD from other condition with ADHD-like symptoms; and (6) to be confirmed by at least two independent studies with high-quality standards. These conditions to elect reliable biomarkers for ADHD are plausible; however, it's a very challenging task due to the specificities of the condition – high symptomatology heterogeneity profile, age differences related to brain maturation processes, gender effects, comorbidities, and multiple etiological mechanisms behind symptoms that are not yet fully investigated.

Thus, a biomarker needs to be measurable, biologically plausible and related to the process that is being assessed molecularly, histologically, radiographically, or physiologically. As an indicator closely related to the process that is being probed, several types of biomarkers can be defined, namely, susceptibility/risk, diagnostic, monitoring, prognostic, predictive, pharmacodynamic response, and safety (please see FDA-NIH Biomarker Working Group, 2016, for more details). Biomarkers can be used alone or in conjunction, and their interplay can play an important role in their sensitivity as an indicator. ERPs are potentially useful as predictive and monitoring biomarkers, as well as diagnostic ones.

A predictive biomarker is used to identify individuals who are more prone to benefit (or not) from exposure to an intervention or to one specific environmental agent (see Fig. 6.2). In this sense, ERPs can be useful to probe specific cognitive processes, which may be related to treatment outcome, especially when using nonpharmacological interventions. For instance, EEG spectral analysis suggests that higher theta power (4–7 Hz) is associated with better response to stimulants in people with ADHD (Ogrim et al., 2014; Olbrich et al., 2015; Sari Gokten et al., 2019). However, the same is true for more intact auditory P3, cue P3, and contingent negative variation amplitudes, as well as reduced go-no P3 amplitudes. By combining behavioral measures with EEG spectra and ERPs measures on a global scale, it is possible to detect gains and side effects of stimulants in children with an accuracy of 91%, a sensitivity of 86%, and a specificity of 88% (Ogrim et al., 2014).

Furthermore, ERPs can be useful as monitoring biomarkers. These biomarkers are a class of indicators that are repeatedly used in order to assess dysfunction/status progression or the effects of the intervention/exposure. In this sense, ERPs can also be useful as biomarkers.

Acute administration of methylphenidate (MPH: a stimulant medication of the central nervous system used in the treatment of ADHD) increased P3 and error-related negativity and positivity amplitudes during go/no tasks in children with ADHD (Groom et al., 2013; Groom et al., 2010). There are also some studies showing the effects of MPH in the N2 component (e.g., Verbaten et al., 1994), although not all reach statistical significant differences (Groom et al., 2010).

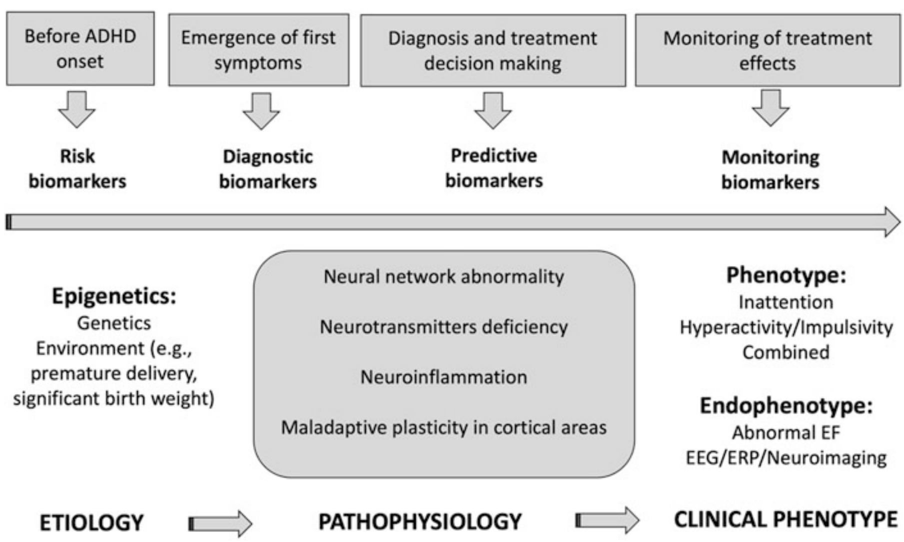

Fig. 6.2 Schematic representation of the factors related to the etiology, pathophysiology, and clinical phenotype of ADHD, as well as the potential use of this evidence to develop different types of biomarkers. EF: Executive functioning; EEG: electroencephalography; ERP: Event-Related Potential. (This scheme was adapted from Guan Lim et al. (2020) and Michelini et al. (2022))

In the following section, we will detail several other ERPs which have been found to be altered in people with ADHD when compared to people without, providing a brief explanation of how those ERPs may be considered putative biomarkers for cognition.

6.4 ADHD and ERPs Usefulness

It is important to highlight that ERPs are not considered to be diagnostic criteria for ADHD. The diagnosis of ADHD is based on a complete history and evaluation of the patient, which is obtained by both structured clinical interviews and ADHD behavior rating scales. The diagnosis is then concluded based on the psychological and behavioral data collected as specified in one taxonomic and diagnostic tool, such as the *Diagnostic and Statistical Manual of Mental Disorders (DSM)* published by the American Psychiatric Association (APA) or *the International Classification of Diseases (ICD)* published by the World Health Organization (WHO).

However, there is a substantial body of literature suggesting abnormalities in the EEG and cognitive ERPs in children, adolescents, and adults with ADHD, and therefore, several putative biomarkers have been proposed for ADHD.

ERPs are a reliable method of correlating brain activity and the underlying cognitive process, such as attention, memory, and executive functions. Thus, in the following section of this chapter, a summary of studies on early and later ERPs in people with ADHD across lifespan (children, adolescents, and adults) is provided.

6.4.1 Earlier ERPs

6.4.1.1 P50

P50 has been used to index sensory gating mechanisms, i.e., the capacity for the brain to selectively process sensory stimuli, such as the ability to filter repetitive/overload information from the environment. The auditory P50 is thought to occur approximately about 50 ms after the presentation of a brief auditory stimulus when repetitive and identical stimuli were presented previously. P50 represents the brain suppression of the evoked response to the brief auditory stimulus and is thought to be an adaptive mechanism of filtering repetitive or redundant sensory information from the environment (Yadon et al., 2009). The sensory gating mechanism studied by P5 can be performed with auditory, visual, and tactile stimuli (Yadon et al., 2009). Failure to inhibit P50 evoked response has been observed in several clinical conditions, such as in people suffering from ADHD.

P50 – sensory gating mechanism (Yadon et al., 2009)
Children and adolescents:
Longer latency, higher amplitude, and ratio values of P50 at baseline
After methylphenidate administration: reduction of the conditioning latency, test latency, and test amplitude
Adults:
Inconsistent findings: normal and abnormal P50 suppression
Abnormal: Less P50 suppression at baseline
Higher mean amplitude of the test stimulus (S2)
Lower P50 suppression (%)
After methylphenidate administration: reduction of P50 ratio values

Children and Adolescents

In a study by Dorucan and colleagues (2011), a total of 22 children with ADHD (from 9 to 14 years old), medication naïve, were assessed and compared to a sample of 18 healthy controls (from 9 to 12 years old). P50 was assessed at baseline for both groups. In the ADHD group, P50 was also assessed following the administration of 10 mg of methylphenidate. Results at baseline showed that the latency, amplitude, and ratio (i.e., second click divided by the first) values of P50 were significantly higher in the clinical group compared to healthy controls. However, there was no difference between groups for P50 conditioning latency and conditioning amplitude. Following methylphenidate administration, compared to baseline, the ADHD groups revealed significant differences in terms of conditioning latency, test latency, test amplitude, and P50 ratio values. This study highlights the possible involvement of P50 in the pathophysiology of ADHD and that the administration of methylphenidate increases the P50 suppression level.

Adults

In a preliminary study by Olincy et al. (2000), a small group of adults with ADHD ($n = 16$), predominantly unmedicated, schizophrenic outpatients ($n = 16$), and healthy controls ($n = 16$) were tested for the auditory P50 inhibition. Results showed a similar pattern to healthy controls ($n = 16$) in terms of P50 suppression. The authors concluded that adults with ADHD may not have the inhibitory sensory deficit that has been repeatedly found in other psychiatric conditions, such as schizophrenia. However, results must be interpreted carefully due to the small sample sizes in the study.

Later, a study by Holstein et al. (2013) tested the sensory gating mechanism in a larger group of adults with ADHD and healthy controls (26/26 participants) using prepulse inhibition (PPI) and P50. In the PPI task, a weak stimulus (called prepulse) is presented right before the presentation of a strong stimulus (called pulse, which elicits a startle response). The priming with the prepulse causes a reduction or suppression of the startle amplitude. Impairments in PPI have been interpreted as being related to sensory gating mechanism dysfunction. Results from this study showed that the participants with ADHD, compared to healthy volunteers, had significantly impaired P50 suppression but not in the PPI, and that was accompanied by impaired cognitive performance.

These inconsistent findings regarding P50 in adults with ADHD may be explained by multiple reasons, such as small sample size (reduced effect size), treatment, and the presence of comorbidities. Thus, in a study by Micoulaud-Franchi et al. (2019), adults with ADHD were assessed for both sensory gating (using a double-click conditioning-testing paradigm and the sensory gating inventory – SGI) and attentional and executive functioning (using an oddball paradigm and neuropsychological instruments). The performance of both measures was correlated in order to study possible associations between sensory input filtering impairment and further executive functioning. Reduced sensory gating, as assessed by the P50 amplitude, and higher distractibility, as assessed by the SGI, was accompanied by reduced P3 amplitude. The results of this study provide evidence of the relationship between the inability of the brain to filter irrelevant information and further alterations to later information processing, as indexed by reduced P3 amplitude in adults with ADHD. Since the sample size was small (a total of 24 adults with ADHD), studies with larger sample sizes are needed to further understand the relationship between these stages of information processing.

More recently, in a study by Sommer et al. (2021), a total of 42 ADHD treatment naïve adults with ADHD, without major comorbidities, were assessed for P50, PPI, and habituation/sensitization at baseline and 6 weeks after administration of methylphenidate. Results from this study showed that adults with ADHD had a similar pattern of PPI, P50, habituation, and sensitization when compared to controls, thus without evidence for gating deficits at baseline. After 6 weeks of treatment, patients reported significantly less symptom burden, as well as improvements in daily life functioning. However, these results did not correlate with changes in the PPI and P50. This study provides evidence of no sensory and no sensorimotor gating deficits in adults with ADHD. Longitudinal studies, following up children with ADHD up to adulthood, could be relevant to possibly evaluate the involvement of brain maturation of specific brain areas and P50 behavior.

6.4.1.2 P100

P100 (or P1) is an ERP that is recorded at occipital lateral sites, starting around 60–90 ms, but reaching a maximum peak between 100 and 130 ms. The onset of P100 is difficult to estimate, either to the overlap with the C100 (another ERP) or to variations due to stimulus contrast. The initial components of the wave seem to originate in the dorsal extrastriatal cortex, and the posterior portion appears to originate in more ventral regions, such as the fusiform gyrus (e.g., Di Russo et al., 2002). In addition to the wave's sensitivity to the stimulus parameters, this wave appears to be sensitive to the direction of visuospatial attention (Hillyard et al., 1998), as well as to the subject's arousal state (Di Russo et al., 2002). P1 seems to correlate with spatial attention and gating to stimulus location (Luck et al., 2000).

P100 – spatial attention and gating to stimulus location (Luck et al., 2000)
Children and adolescents: Delayed latency of P100 and reduced amplitude of P100 during NoGo trials was observed, over the occipital sites. *Adults*: Reduced P1 amplitude at posterior sites (i.e., occipital and inferotemporal scalp areas), significantly correlated symptoms severity and ADHD subtype.

Children and Adolescents

There is evidence of impaired early (sensory) information processing in people with ADHD, which may contribute to some of their symptomatology. Nazari et al. (2010) conducted a study in which brain activity was monitored using a high-resolution EEG while 15 children with ADHD and 15 matched controls performed a Go/NoGo paradigm. Children with ADHD, compared to controls, had decreased accuracy towards Go trials and higher omission errors. Additionally, delayed latency and reduced amplitude of P100 during NoGo trials were observed over occipital sites (using source location with Standardized low-resolution brain electromagnetic tomography – sLORETA). The authors concluded that children with ADHD, compared to controls, seem to have impaired early integration of visual stimulus over the occipital sites. However, these results need further confirmation in larger sample sizes.

Adults

In one study by Papp et al. (2020), 26 adults with ADHD and 26 matched controls were evaluated with high-density EEG systems. This study showed reduced P1 amplitude at posterior sites (i.e., occipital and inferotemporal scalp areas) in adults diagnosed with ADHD, as compared to controls. This reduction in the P1 component was significantly correlated with symptom severity, as measured by the Conners' Adult ADHD Rating Scale. In addition, patients who were predominantly inattentive exhibited smaller P1 amplitudes as compared to those who were predominantly hyperactive (which exhibited higher P1 amplitudes). The results of this study provide preliminary evidence of deficits in the early sensory processing as indexed by the P1 amplitude and their possible association to severity and subtype of ADHD.

However, not all studies have found changes to the P100 component in adults diagnosed with ADHD. For instance, in the study by Mauriello et al. (2022), the neural basis of eye-gaze perception in adults with ADHD ($n = 23$) as compared to controls ($n = 23$) using the delayed face-matching task with neutral faces was studied. Results showed similar microstates for both P100 and N170 components between adults with ADHD and controls. N170 is an ERP elicited by faces in the lateral occipital zone, especially in the right hemisphere, at approximately 170 ms (Rossion et al., 1999).

6.4.1.3 N100

The N100 component has several subcomponents. The first peaks around 100–150 ms after stimulus onset in anterior electrodes and two components in the posterior zones (at least) that peak between 150 and 200 ms after stimulus presentation, one coming from the parietal cortex and another from the lateral occipital cortex. These components are affected by visuospatial attention (e.g., Mangun, 1995) and exhibit greater amplitudes when participants were asked to perform a discrimination task, leading to the hypothesis that these components are related to any type of discriminative processing (Hopf et al., 2002; Vogel & Machizawa, 2004). The auditory N100 comprises numerous components, including a frontocentral component that peaks about 75 ms and originates from the auditory cortex in the dorsal zone of the temporal lobe. A vertex-maximum potential of uncertain origin around 100 ms and a more diffused lateral component that peaks at 150 ms and appears to be formed in the superior temporal gyrus. This component is subject to attention influences.

N100 – discrimination processing, affected by visuospatial attention; processing of unexpected stimuli (Sur & Sinha, 2009)
Children and adolescents: Reduced amplitude of N2 versus no evidence of reduced amplitude *Adults*: Reduced N2 amplitude in response to target stimuli during a visual continuous performance task (CPT)

Children and Adolescents

In a pilot study by Pliszka et al. (2000), a total of 10/10 children with ADHD and controls responded to a stop signal task while EEG was recorded. Results showed that children with ADHD, contrary to controls, had a reduced N200 amplitude in response to all stop signals over the right inferior frontal cortex. The pattern of N200 amplitude significantly correlated to performance in the inhibitory task. The results of this study provide preliminary evidence that children with ADHD may have difficulties in early information processing related to response inhibition, as assessed by N200 over right frontal areas. In line with this study, Yong-Liang et al. (2000) studied brain inhibitory processes in a total of 21/21 boys with ADHD compared to controls during a Go/No-go task while ERPs were recorded. Compared to controls, ADHD children made fewer correct responses in Go and NoGo trials. The ADHD group showed reduced amplitude of the N200 to NoGo trials, only when the task was performed for the first time. In addition, results showed a larger amplitude of the N200 for NoGo trials compared to Go trials for both groups. The authors discussed that these results might indicate that children with ADHD have difficulties in inhibitory regulation rather than an inhibit deficit, at least as detected in the early information process (as indexed by N200 amplitude).

In a study by Fallgatter and colleagues (2004), 16 unmedicated children (aged 7.17 to 11.67) with ADHD and 19 controls (aged 8.2 to 11.8 years old) conducted a visual Go/NoGo task (Continuous Performance test – CPT) while EEG was recorded. In NoGo trials, there were no differences between groups for N2OO. Indeed, both the ADHD group and the controls demonstrated a similar pattern of increased amplitude in NoGo trials when compared to Go trials. Therefore, this study did not corroborate the difficulties of inhibitory control as indexed by N2.

Adults

In a study by Kaur et al. (2019), a total of 35 young adults with ADHD and 35 controls were assessed using a visual continuous performance task (CPT), while EEG activity was recorded to study three ERP components in response to standard and target stimuli: N1, N2, and P3. Concerning N1, results showed a reduction in terms of amplitude in response to target stimuli, which can be interpreted as difficulties in discrimination of these specific stimuli at early stages of the information processing, such as sensory processing.

6.4.1.4 Error-Related Negativity (ERN/Ne)

The ERN is a negative component that arises when participants make mistakes/respond incorrectly in sensorimotor or similar tasks. This component has been identified by different investigators in different laboratories (e.g., Dehaene et al., 1994; Gehring et al., 1993). This component can be evoked in reaction time tasks that imply a choice, for example, when participants must respond to two auditory (or visual) stimuli by using one of their hands. An incorrect response consists, for example, of using the left hand to respond to a stimulus that should be responded to with the right hand. In these situations, a negative deflection in the ERP waveform appears (i.e., the ERN), with a peak occurring around 50–150 ms after the wrong answer, with the maximum amplitude being captured by fronto-central electrodes (Falkenstein et al., 2000). This component also seems to appear in Go/NoGo tasks when participants respond incorrectly to the NoGo stimulus (Scheffers et al., 1996).

ERN/Ne – Error detection and error correction
Children and adolescents:
Decreased ERN amplitude after impulsive errors
Adults:
Reduced amplitude of ERN in adults

Children and Adolescents

In a study by Liao and colleagues (2018), children with and without ADHD who made impulsive errors were assessed. Children with ADHD exhibited decreased ERN amplitudes when performing impulsive errors than children without.

In another study, no differences were found between children with and without ADHD in the ERN component while performing a Go/No Go task; however, children with ADHD showed a diminished error positivity (Pe) (Wiersema et al., 2005).

Adults

In the study by Marquardt and colleagues (2018), a total of 27 adults with ADHD and 28 controls performed a modified flanker task. The authors assessed behavioral task performance, ERPs, and symptomatology with the Adult ADHD Self-Report Scale (ASRS). Compared to normal development controls, ADHD adults exhibited increased error rates in incompatible trials, and those who scored higher in the ASRS, were the ones with the higher error rates. The clinical groups also showed reduced amplitude of the ERN and Pe. This study showed evidence error processing deficits in adults with ADHD that were observed both in the behavioral data and the reduced ERN and Pe amplitudes.

6.4.1.5 P200

P200 usually appears in anterior and central locations, and the component is greater for stimuli that contain characteristics of targets. Moreover, this effect is potentiated when the targets are relatively infrequent (Luck & Hillyard, 1994b). It is also important to highlight that the P200 and the P300 components are different. P200 occurs when the target has very simple characteristics, while P300 can occur with very complex categories (Luck, 2005). In posterior electrodes, it is very difficult to distinguish P200 from the superimposed N100, N200, and P300.

P200 in Children/Adolescents

P200 – early orientation to stimulus (Sur & Sinha, 2009)
Children and adolescents:
Increased amplitude – difficulties in early orientation to a stimulus
Amplitude of target and standard P2 is enhanced in children with combined ADHD subtype
Shorter latencies
Adults:
Abnormal ERP waveform related to decreased activity over the left midline/cerebellum
After methylphenidate:
Increased latency of P200 after high dosage, however, no effect on amplitude

Children and Adolescents

Most studies did not find changes in the early P2 ERP component in children and adolescents with ADHD, when compared to controls. In a study by Sunohara and colleagues (1999), a total of 20/20 children with ADHD/controls responded to a continuous performance task in which individuals had to identify repeating alphabetic characters while EEG was recorded to study ERPs elicited by corrected responses during the behavioral task. Both groups were assessed at baseline naïve to medication, on placebo, and for the ADHD group, following administration of a low dosage of methylphenidate (0.28 mg/kg) and after administration of a high dosage of methylphenidate (0.56 mg/kg). Behavioral data at baseline showed that the groups of children with ADHD were more impulsive and inattentive than controls and had shorter latencies of the P2 and N2 ERPs, following longer P3 latencies. After administration of a low dosage of methylphenidate, children with ADHD showed reduced impulsivity (expressed by a reduced number of false alarms) and reduced P3 latency. High dosage of the medication, on the other hand, not only reduced impulsivity and inattention but also increased latencies of both P2 and N2 ERPs, and decreased latencies of P3. No effects were found for amplitudes of the ERP in this study. This study provides important implications of the differential effects of different dosages in the modulation of ERPs.

In the study by Gow et al. (2012), a total of 54 adolescents with ADHD, predominantly medication naïve, were assessed for conflict and response inhibition using a Go/NoGo ERP task. Results were compared to a sample of 55 healthy volunteers. Adolescents with ADHD showed higher inhibitory deficits compared to controls in both inhibitory measures – higher commission (NoGo trials) and higher omission errors and slower reaction times (Go Trials). The behavioral deficits were accompanied by significant changes in late ERPS across central and centroparietal sites (N2, P3a, and P3b – discussed in the following sections of this chapter), but no differences between the ADHD and control groups were found for the early P200 component.

In another study, a total of 20 children with ADHD (combined type) and 20 controls responded to an auditory oddball while electrophysiological brain activity was registered (Senderecka et al., 2012). Results showed that children with ADHD had significantly increased amplitude of P2 compared to controls. Enhanced amplitude of P2 may be interpreted as difficulties in early orienting to stimulus that affect later stages of the information processing.

Adults

Most of the studies with P200 in ADHD have been conducted with children and adolescents. One study (2022) examined earlier and later components related to eye gaze perception. Despite not finding differences in terms of the earlier components, P200 was found to be altered and thus was related to reduced activity over the left midline/cerebellum.

6.4.1.6 Mismatch Negativity (MMN)

The mismatch negativity is a wave component, which appears more centrally in the midline, between 160 and 220 ms, in a condition where repeated stimuli are occasionally replaced by a mismatch one. This effect appears, even when the presentation of stimuli has nothing to do with the task, but it can be attenuated if, after the presentation of a stimulus in one ear, the task is focused on the stimuli in the other ear (Woldorff et al., 1991). This is thought to be related to an automatic process that compares the afferent stimulus with the preceding sensory memory trace (Luck, 2005).

The MMN ERP component has been widely studied in children, adolescents, and adults with ADHD. This component represents the automatic and preattentive auditory processing and the orientation to stimulus not related to the ongoing task (distractibility) (Näätänen et al., 2012). MMN has been proposed as a potential biomarker for assessing the neurophysiological mechanisms of ADHD, since people with this condition show difficulties in focusing and maintaining their attention on ongoing tasks. In addition, some studies have correlated dysfunction of N-methyl-D-aspartate (NMDA)-type glutamate receptors to MMN amplitude reduction in children with ADHD (Chang et al., 2014).

Children and Adolescents

A meta-analysis from 2016 (Cheng et al., 2016) included six articles with ten individual studies probing the potential changes in MMN in children with ADHD. The pooled effect size of 0.28 (95% CI: 0.03–0.53) suggests that children with ADHD exhibited decreased MMN amplitudes when compared to children without. Thus, suggesting a decline in central auditory processing in children with ADHD.

Adults

Despite promising evidence of reduced MMN amplitude observed in children with ADHD (Cheng et al., 2016), less is known about alterations of the MMN in adults with ADHD. However, a study by Kim et al. (2021) compared the MMN in drug-naive adults with ADHD to healthy controls and showed that patients with ADHD exhibited: (1) reduced MMN amplitudes at the frontocentral sites; (2) decreased MMN source activities in both frontal, temporal, and limbic sites; (3) source MMN activities were negatively correlated with ADHD symptom scores; and (4) the MMN source activity features showed an accuracy, sensitivity, and specificity of 81.01%, 82.35%, and 80%, respectively.

6.4.1.7 N200

A repeated nontarget stimulus will elicit an N200 deflection that can be considered as its basic component (Woldorff et al., 1991). If other stimuli (called deviants) arise along a chain, increased N200 amplitudes are observed. If these deviants are nontargets, then a MNM is presented (which does not appear to occur in visual terms). If these deviants have to do with the task, then N2b appears (MNM is sometimes called N2a). This component is larger for less frequent targets and is seen as a stimulus categorization signal. Visual and auditory deviants will cause an N2b if they are relevant to the task, and the effects are greater under central regions for auditory stimuli and in posterior regions for visual ones (Simson et al., 1977). It is not known whether the auditory and visual components represent homologous functions in neuronal terms (Luck, 2005).

When visually studying the stimuli, in addition to a temporal sequence, we can study the stimuli in a spatial distributed manner, in which there are several identical stimuli, plus one that is deviant. When this happens, there are three distinct components (Luck & Hillyard, 1994a): the first is an anterior bilateral response present even when the deviant is not a target (but it is not automatic like MNM, as it is only present if participants are looking for targets); two other subcomponents arise only if the target is relevant to the task (or resembles it as such). One is N2b, which has a bilateral distribution and is sensitive to the probability of the stimulus, and the second is N2pc (contralateral posterior), since it appears in the posterior regions in a contralateral position to the target. N2pc is not sensitive to the probability of the stimulus and reflects the focus of spatial attention on the location of the target (Luck & Hillyard, 1994a). There is still contralateral negativity during visual working memory tasks, but it has a more parietal-focused distribution and seems to reflect a certain aspect of working memory (Vogel & Machizawa, 2004).

N200 – Signal detection and discrimination
Children and adolescents: Reduced amplitude – deficits stimulus detection and discrimination, as well as difficulties in conflict monitoring. *Adults*: Reduced amplitude of the N2 component in response to both standard and target stimuli during CPT was observed compared to controls.

Children and Adolescents

In the previously described study by Nazari et al. (2010) (Sect. 6.4.1.2 of this chapter), a delayed latency of the N200 (similar to P200) in children with ADHD compared to controls was found. These results, despite preliminary, due to the small sample size, may be interpreted as a delayed signal detection and discrimination during task performance in the clinical group, may be due to early difficulties in visual sensory integration over the occipital sites, as evidenced by the delayed latency of P200 and reduced amplitude of the P100 for NoGo Trials.

In a study by Satterfield, Schell, and Nicholas (1994), a total of 36/35 children (aged 6 years old) with ADHD and controls, respectively, responded to a two-choice discrimination task, and ERPs were registered. Children with ADHD exhibited decreased amplitudes of N1, N2, P3b, and visual N2 in response to the attended target stimuli.

In a study by Tsai, Kun-Long, and Hui-Hua (2012), ERPs (N1, P2, N2, and P3) elicited by an auditory oddball paradigm were assessed in a group of 50 children with ADHD and 51 controls. Delayed N2 latencies were registered at the Pz site, as well as longer latencies and lower amplitude of P3 were found in children with ADHD compared to controls. No differences between groups were found for both N1 and P2. The delayed latency of the N2 may be interpreted as difficulties in signal detection and discrimination (Barry et al., 2003).

Similar to the previous study, in a study by Senderecka et al. (2012), a total of 20 children with ADHD (combined type) and 20 controls responded to an auditory oddball while electrophysiological brain activity was registered. Despite similar task performance for both groups, there were differences between groups in the ERPs elicited by both target and standard stimuli. Namely, children with ADHD showed reduced amplitude of the N2 compared to controls. Children with ADHD also showed increased P2 amplitude and reduced amplitude of P3 in response to targets, compared to controls. Additionally, in the ADHD group, the difference in the amplitude of P3 between targets and standards was smaller, especially in the right hemisphere. The results of this study provide evidence on alterations of the information processing in children with combined ADHD type. Reduced amplitude of the N2 can be interpreted as impaired stimulus detection and discrimination, as well as difficulties in conflict monitoring.

Adults

In a study by Kaur et al. (2019), a reduced amplitude of the N2 component in response to both standard and target stimuli during CPT was observed, in adults with ADHD, when compared to controls. These results provide some evidence of early information processing in adults with ADHD, namely stimulus categorization and discrimination.

In conclusion, multiple studies have reported decreased amplitude of the N2 in frontal and parietal sites (Satterfield et al., 1994; Senderecka et al., 2012; Tsai et al., 2012) in children with ADHD when compared to controls. Reduced N2 amplitudes may be associated to difficulties in stimulus discrimination and difficulties in conflict monitoring.

6.4.2 Later Cognitive Event-Related Potential

6.4.2.1 P300

P300 is probably the most studied waveform component and at the same time is still a mystery. It arises when an update involving attention processes and initial stimulus processing is required (Polich, 2007).

There are two main components, P3a (frontal) and P3b (parietal). P3b only appears when changes are relevant to the task. Despite numerous studies, there is still no consensus about what P300 represents and Donchin's formulation (Donchin, 1981) as a working memory index of the neuronal activity involved in updating the representation of stimuli. The main characteristic of P300 is its sensitivity to the probability of stimuli: the amplitude of P300 increases with a decrease in the probability of the stimulus; the amplitude increases when the target is preceded by an increasing number of nontargets; is the probability of the defined class of stimuli for the task and not the probability of the physical stimuli.

The amplitude of P300 is higher when the participants dedicate more effort to carrying out a task, and it can be used as a measure of resource allocation (e.g., Isreal et al., 1980). On the other hand, there is a decrease in amplitude if the subject has uncertainties about whether a stimulus will be a target or a nontarget.

$$P3_{\text{amplitude}} = U \times (P + R)$$

Probability variation (P), Uncertainty (U), and Resource allocation (R) (Johnson Jr, 1984, 1986).

Since the P300 wave depends on the probability of the task, P300 will only appear when the stimulus is categorized according to the task rules, and any or all manipulations that postpone the categorization (from the time required for processing in terms of sensory data, as well as categorization) should increase latency. However, no changes are found in terms of postcategorization manipulations (e.g., increased time to respond after stimulus presentation). If the stimuli are perceptually degraded, there is an increase in latency (consonant with the hypothesis of manipulation prior to the categorization process).

P300: Stimulus processing and evaluation of task-relevance; updating working memory; event categorization; attentional resource allocation and reorientation (Polich, 2007)

Children and adolescents:

Reduced amplitude and longer P3 latencies when compared to normal development control children

Longer latency – slower speed processing

Reduced amplitude – inhibitory control difficulties

Adults:

Reduced amplitude

After methylphenidate:

In children with ADHD, both low and high dosage lead to a reduction of the P3 latency.

No effects on P3 amplitude.

Children and Adolescents

In an early study by Strandburg et al. (1996), children with ADHD (and healthy controls) responded to a Continuous Performance Task (CPT) while ERPs were recorded. In general, the authors showed that the clinical sample had longer latencies and made more errors, for both single and dual-target trials of the CPT, than the control sample. Despite the pattern of the early ERPs being similar to both groups, the later processing was clearly different since ADHD children had longer P3 latencies and reduced amplitudes, as compared to the control group. These results suggest that the early stage of the processing – meaning the sensory processing and the mobilization of resources to the task was similar for both groups. However, there was a reduced involvement in the later cognitive processes, which included postdecisional processing.

In a study by Sunohara and colleagues (1999) previously described (Sect. 6.4.1.5), the administration of low and high dosages of methylphenidate in children with ADHD led to a reduction of the P3 latency. No effects were found for amplitudes of the ERP in this study. This study provides important implications of the differential effects of different dosages in the modulation of the ERPs,

In the study by Seifert et al. (2003), a total of 17 treated and untreated hyperactive boys (aged 7–11 years old) and a total of 20 healthy controls were tested using the continuous performance task (CPT) and ERPs to evaluate brain electrical activity related to attention and response to methylphenidate medication. Results showed reduced amplitudes of P3a in nonmedicated ADHD individuals compared to matched controls. There was also a stimulant effect, as children under methylphenidate exhibited no differences in the segment 3 amplitudes.

In the previously described (Sect. 6.4.1.7) study by Fallgatter et al. (2004) unmedicated boys with ADHD and 19 controls performed a visual Go-NoGo task while EEG was recorded. Results regarding P300 showed reduced amplitude of P3 in NoGo trials at the Cz site, compared to controls, accompanied by reduced Nogo-related amplitude over frontal sites. The results of this study may indicate that nonmedicated children with ADHD have deficits in response control indexed by P3 over the prefrontal cortex.

In a study by Ozdag et al. (2004), ERPs were studied in a sample of boys with ADHD before and after treatment with methylphenidate, a stimulant medication of the central nervous system that is commonly used to treat ADHD. At baseline, authors compared early and later ERPs in the clinical sample and compared to healthy controls and showed longer latencies and small amplitude of the P3 and N2 over parietal and frontal sites in the clinical group. After treatment, latencies of both P3 and N2 over the parietal site and P3 over the frontal site decreased, and the amplitude of P3 increased over the parietal and frontal sites as well as the amplitude of N2 over the parietal site. This study provided evidence on early and late information processing deficits, including attention deficits and discrimination, in boys with ADHD as indexed by the ERPs. It was also shown that treatment response to methylphenidate could be indexed to changes in ERP, which can be useful as potential biomarkers of treatment response.

There is also substantial evidence that children with ADHD have difficulties in controlling involuntary attention, which may be related to the distractibility profile, as assessed by late ERPs. In a study by Gumenyuk et al. (2005), children with ADHD and controls responded to a visual discrimination task, while distracting novel sounds were presented during task performance. Children with ADHD, when compared to controls, had an overall low performance in the task, and also showed an increased number of omitted responses after the distracting sound. P3 (a- 180–240 ms and b- 300–350 ms) and late negativity (LN) ERPs were assessed. Children with ADHD exhibited reduced amplitudes of P3a over left fronto-central sites, and the later P3 was enhanced over the left parietal sites. Reduced LN amplitude and shorter latencies in frontal sites were found for the ADHD group, when compared to controls.

Later a study by Tsai et al. (2012) also showed a similar pattern of longer latency and a decreased amplitude of P3 in children with ADHD compared to children without, suggesting impairments in the processing speed and also in later information processing such as decision-making and inhibitory control. Another study (Yamamuro et al., 2016) also demonstrated longer latencies and reduced amplitude of P3 in children and adolescents with ADHD, as compared to controls, at fronto-central, centro-parietal, and parietal sites, as well as a positive correlation between the level of prolongation of the P3 waveform with the severity of ADHD symptoms of inattention. The authors concluded that this study provided preliminary evidence of a possible correlation between the level of inattention and the degree of alteration in terms of P3 latency and amplitude. Thus, highlighting the potential of the P3 component as a suitable method of assessing ADHD symptoms severity.

In the study by Senderecka et al. (2012), described previously, children with ADHD (combined type) showed reduced amplitude of P3 in response to targets when compared to controls. Additionally, in the ADHD group, the difference in the amplitude of P3 between targets and standards was smaller, especially in the right hemisphere. The reduction of the P3 amplitude, as well its asymmetric distribution (i.e., towards the right hemisphere), may be associated with deficits in the later information processing, namely higher order executive processes, including attention allocation, evaluation, as attentional deficits are found to be related to the right hemisphere.

A large-scale clinical study by Münger et al. (2021) evaluated ERP in people with ADHD across lifespan (a total of 447 children, adolescents, and adults) and, similarly to previous studies, people with ADHD showed longer latencies, reduced amplitudes of the ERPs accompanied by the increased number of errors and larger reaction time during task performance, as compared to controls. In addition, this pattern was similar across all ADHD subtypes (combined, inattentive, and hyperactivity/impulsive), as well as to those with low and high self-reported ADHD burden. Contrary to the study by Ozdag et al. (2004), in this study, the authors did not find any differences in terms of behavioral and ERP outcomes between participants taking methylphenidate and those that were naïve to medication. However, the small-to-moderate effect sizes in the present study prevent us from drawing definitive conclusions regarding the utility of these neurophysiological markers for diagnostic purposes.

A cross-sectional, observational, longitudinal study by Münger et al. (2021), a total of 239 children and adolescents with ADHD and 91 healthy controls were assessed five times in a period of 2 years for symptoms and their performance in a cued Go/NoGo task during the registration of the ERPs. Results at baseline showed that the group with ADHD, as compared to controls, had higher reaction time variability, increased number of omission and commission errors, and reduced amplitude of both CNV and P3d (i.e., the difference between go and no go trials) ERPs. As expected, both groups increased their behavioral task performance over the 2 years, however, with a different pattern between ADHD and controls. Additionally, the groups of ADHD showed amelioration of symptom burden by 22%. However, despite slight changes over the 2 years of the amplitudes of both cue P3, CNV, and N2d, and mild differences between the two groups, there was no clear correlation between changes in symptomatology, behavioral, and ERPs data. The results of this study seem to support that neurocognitive deficits and the underlying ERPs correlates may be independent of ADHD symptom alleviation.

Adults

In the study by Marquardt and colleagues (2018) previously described in this chapter (Sect. 6.4.1.4), in which a total of 27 adults with ADHD and 28 controls performed a modified flanker task during EEG. Reduced amplitude of P3 in incompatible trials of the modified flanker task was observed in the ADHD group, and this result was inversely correlated to symptoms. The results of this study provide evidence about difficulties in performance monitoring in adults with ADHD that were detected by reduced amplitude of P3. Reduced amplitude of the P3 component in response to both standard and target stimuli during CPT was observed in the study by Kaur et al. (2019) in adults with ADHD compared to controls. These results provide some evidence of late information processing in adults with ADHD, namely attentional resources allocated to stimuli.

Later, Münger et al. (2022), in a similar study design, tested symptom burden, performance in a cued Go/NoGo task, as well as the ERPs in adults with ADHD ($n = 210$) and healthy controls ($n = 158$), aged between 18 and 62. The clinical group was tested five times, and the control group three times over 2 years. Results at baseline showed that the group with ADHD, as compared to controls, had higher reaction time variability, increased number of omission and commission errors, and reduced amplitudes of N2d, CNV, cueP3, and P3d. Over the 2-year period, the groups of individuals with ADHD improved in their self-reported symptomatology. No changes in behavioral measures related to cognitive task performance were observed; however, the amplitudes of cueP3, P3d, and N2d decreased in both groups. Similar to what was shown in the previous study with children and adolescents with ADHD, there was no robust evidence of the association between amelioration in ADHD symptomatology and the behavioral and ERPs metrics.

6.4.2.2 Contingent Negative Variation (CNV)

The contingent negative variation (CNV) is a slow wave, later-stage ERP that is thought to reflect motor preparation for the response and is related to stimulus expectation (Walter et al., 1964). Despite not having a defined time window – it usually occurs after 1000 msec after stimulus presentation.

CNV – motor preparation and stimulus expectation (80)
Children and adolescents:
Reduced CNV amplitude
Adults:
Reduced CNV amplitude

Children and Adolescents

Several studies have probed the CNV component in children and adolescents with ADHD. For instance, Albrecht et al. (2013) showed that children with ADHD and their siblings had reduced CNV after cue when compared to controls. Furthermore, in adolescents (and young adults), CNV was also found to be smaller in people with ADHD than in normal developing controls (Albrecht et al., 2013).

Adults

The CNV seems to follow a similar pattern in adults. McLoughlin et al. (2010) used a CPT task in 21 adults with ADHD (and 20 controls). They found an interaction effect while the CNV amplitude decreased for the ADHD group during a flanker task, it increased for the control group. In another study, neurofeedback was used with adults with ADHD (Mayer et al., 2016). After 30 sessions of slow cortical potential neurofeedback, CNV amplitude increased. In another study, the fluctuating response times and ADHD were probed using ERPS (Cheung et al., 2017). The authors showed that adults with ADHD failed to show an increase in the CNV amplitude from baseline to the fast incentive condition, thus suggesting that CNV is attenuated in people with ADHD and its potential inability to adjust the preparatory state. However, there are also studies in which there were no significant differences in terms of CNV between adults with and without ADHD (Grane et al., 2016).

6.5 ERP Putative Biomarkers and Brain Maturation Across Lifespan

There is a substantial body of evidence that children and adolescents with ADHD have smaller brain volumes in multiple regions (Castellanos et al., 2002), and that structural changes are intercorrelated to functional impairments (Albajara Sáenz et al., 2019). Although symptoms of ADHD may persist over time, it is also expected that symptoms in adulthood may be exhibited with a different pattern (e.g., hyperactivity express differently in children and adults with ADHD), probably due to brain maturation of specific brain networks across lifespan (Koumoula, 2012). In addition, the presence of six symptoms is required to diagnose ADHD in children and adolescents (up until 17 years old), and only five specific symptoms are required to diagnose ADHD in adults, according to DSM-5. Therefore, there is some evidence that brain maturation of people diagnosed with ADHD may follow a similar pattern when compared to people without the clinical condition; however, it may occur at a slower rate (Bouziane et al., 2017; Krain & Castellanos, 2006).

The study of putative biomarkers is an area of growing development in ADHD. Particularly those low-cost and noninvasive assessments such as EEG/ERPs can be very helpful not only for diagnosis but as predictors or monitoring biomarkers. These candidate ERP markers may be useful in the future to stratify patients according to their profile to specific treatments (Michelini et al., 2022).

However, more studies are needed to evaluate these candidate biomarkers across lifespan. As the brain changes over time, it is expected that the pattern of each marker may also follow the brain maturation over time. In this chapter, a summary of the evidence on candidate ERPs markers across lifespan, and it is evident some differences overtime is provided, despite the reduced number of studies in adults with ADHD.

6.6 Final Remarks

ADHD is a neurodevelopmental disorder and, to the date, there are no brain-based methods validated for diagnostic purposes. Given the heterogeneity that characterizes this disorder, it is expected that multiple biomarkers are needed to capture all ADHD profiles across lifespan.

In this sense, ERPs may be useful as candidate biomarkers, especially because they seem to be sensitive to some brain processes that have been found to be altered in ADHD, as well as to respond to stimulant treatments.

From the literature, one can state that difficulties in filtering sensory information may be present in people with ADHD and can influence further information procession at high-order levels, ultimately affecting executive functioning.

In general, most studies suggest that people with ADHD, compared to controls, show an increased number of errors and large reaction time variability in the performance of neuropsychological tasks assessing executive functioning, as well as reduced amplitudes and increased latencies of ERPs. However, the effect sizes of these differences are rather small to moderate, which prevents us from drawing definitive conclusions about the use of these measures as reliable biomarkers for ADHD.

Detection of reliable electrophysiological markers, such as cognitive ERPs, in people with ADHD across the lifespan is needed to support clinicians to provide appropriate diagnosis and treatments to patients. Brain development and maturation across lifespan may interfere with the pattern of the biomarkers, and, therefore, more studies are needed in order to determine the accuracy, sensitivity, and specificity of isolated or combined biomarkers. In addition, given that there have been limited studies exploring biomarkers in adults with ADHD, further studies are warranted to identify biomarkers for adult ADHD as compared to healthy controls.

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7 Adult Persons with ADHD and Their Lifestyle

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7.1 Introduction

There has been a dramatic increase in overweight and obesity in the whole society. The reasons are many, but above all it is due to changes that society and its environment have undergone in the recent decades which resulted in more sedentary lifestyles and more fast-food consumption. Research shows a shortened lifetime expectancy in adults with ADHD and one reason for that is poor lifestyle habits, e.g., sedentary lifestyle, poor diet habits, inadequate coping strategies for mental illness, and loneliness.

In the field of health sciences, it is important to alleviate suffering and to promote health. Persons who feel stress, anxiety, and are depressed lose power over their own life choices and over their ability to change their lifestyle habits. In a survival mode, there is no room to plan or think about what healthy food to consume or to exercise because it is healthy. To survive the moment, only what needs to be done is done. In today's society, proactive care is important because healthcare costs have increased. The most expensive diseases are lifestyle diseases such as cardiovascular disease, diabetes, and cancer. The causes of lifestyle-related diseases are often living conditions and lifestyle habits.

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Persons with ADHD have complex health situations. They are persons with different backgrounds, experiences, desires, and dreams, but at the same time they struggle with disabilities and suffer from symptoms of mental illness. Many persons with ADHD have feelings of inability in daily activities, have experiences of exclusion from society, and have depressive symptoms. It is therefore important to provide support for an improved lifestyle and for improved living conditions, e.g., return to work for persons with ADHD. It is very important to support and maintain health in adults with ADHD for future physical, mental, and existential health for them and their children, as well as for society.

ADHD is a public health problem that has increased in the adult population (Nylander et al., 2013). Several large studies in Europe and globally show an elevated risk of dying prematurely for people with an ADHD diagnosis (Dalsgaard et al., 2015; London & Landes, 2016; Barkley & Fischer, 2019). Taken together, it is ADHD and mental illness that provide the greatest healthcare strain on society (Linden, 2017; Vigo et al., 2016). In addition, adults with ADHD have more difficulties in everyday life compared to other mental illnesses (Holst & Thorell, 2020). The Nordic countries have relatively small social and economic differences, but despite this, inequality in health has increased (Bartelink et al., 2019). It is well known that persons with ADHD have difficulty reaching higher education. Among them, poverty and low

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socio-economic status are related to subordinate health and barriers to access to health care (Russell et al., 2016; Hegelund et al., 2019). A study by Bixby et al. (2019) also shows another connection: living in smaller cities can mean an extended risk of increased BMI. In addition, household income can be an obstacle to healthy lifestyle habits (Weissenberger et al., 2017). ADHD is also linked to significant costs for health care and financial losses for society (Libutzki et al., 2019; Daley et al., 2019). This indicates that large amounts of sick leave need to be prevented. Low socio-economic status and poverty are linked to a number of negative health outcomes for people with ADHD in the adult population (Russell et al., 2014; Young & Goodman, 2016). According to a European study, sickness benefit is generally more common in adults with ADHD (Trantou et al., 2018). Sick leave is an indicator of poor health status, but other factors are also important for achieving health such as education, employment, working conditions, and sufficient income to be able to live a healthy life (Marmot, 2017). In addition, negative attitudes in health care and social services can lead to poorer health because persons with ADHD may feel like being a burden when seeking treatment (Matheson et al., 2013).

A search was performed combining the words ADHD and adult with lifestyle. Search fields that were used were titles, abstracts, and keywords. Truncation of the words was applied to search for word stem derivations such as plurals. In addition to the word lifestyle and variants thereof, other related words such as diet, physical activity, and obesity were tried. To expand further, we also used concepts such as working life, social life, and loneliness. Searches were performed not only in standard citation databases such as Web of Science and Scopus but also in more specialized bibliographic databases such as PUBMED, CINAHL, and Cochrane. After duplicate removal had been performed manually and using reference management software, the results were reviewed. Search hits from the last 20 years only amounted to a few hundred documents. Many of these were irrelevant, and others were only marginally of interest. In the final analysis, only a dozen or so could be deemed to be relevant to the intention of the search. Therefore, one can conclude that this is a research area that has not been extensively explored.

7.2 Living with ADHD

Adults with ADHD struggle and strive to live as ordinary a life as possible despite feelings of being different and living with disabilities. What a feeling of well-being means is probably defined in the same way for persons with ADHD as in the general population.

Not all adults with ADHD suffer from poor health but many do. Being an adult with ADHD and other neuropsychiatric disabilities is, just as for persons with mental illness, a common cause of longer and shorter sick leave from work in OECD countries (De Vries et al., 2018).

Persons with ADHD are as different from each other as people in the general population and so also their problems. Some of them experience that they do not want to be without their diagnosis and that they are more creative and productive, thanks to their ADHD, both at home and at work (Hansson Hallerod et al., 2015; Schrevel et al., 2016). A review study describes that adults with ADHD develop their own coping strategies to achieve a healthy life, which can be both challenging but also rewarding (Bjerrum et al., 2017).

The experience of living with ADHD and mental illness is individual. But in general, living conditions for adults with ADHD and mental illness are more complicated than for many others. Living conditions mean individual, social, socio-economic, and environmental circumstances beyond the individual's control (Marmot, 2017). The life situation of persons with ADHD affects a number of different areas in both their professional and private lives, such as social relationships, school, and work (Jones & Hesse, 2014; Bjerrum et al., 2017). Persons of all ages living with mental illness describe suffering related to life, illness, and health care (Eriksson, 1992). Adults with ADHD have reported that they have struggled to get the right diagnosis and experience a lack of professional help and stigmatizing attitudes (Stickley et al., 2019; Masuch et al., 2019). Many also experience helplessness, lack of being accepted, and poor self-confidence and tend to develop negative attitudes toward themselves, which is partly due to the fact that they feel different. This impairs treatments, adherence to various treatments, quality of life, and well-being (Schrevel et al., 2016; Watters et al., 2018; Bjerrum et al., 2017). Adults with ADHD struggle to cope with stressful life events and may develop dysfunctional behavior (Bramham et al., 2009). In addition, neglect and negative attitudes in health care can lead to poorer health for adults with ADHD and lead to a feeling of insecurity when seeking care (Eklund et al., 2016).

7.2.1 Cognitive Impairments Limit Daily Life

Many persons with ADHD may have difficulty managing their daily lives due to executive disabilities with concentration and memory difficulties that can lead to problems starting and completing tasks (Adler et al., 2017). They may also experience limitations in managing stress, planning, meeting appointments, absorbing information, working sustainably, and purposefully. (Guldberg-Kjar & Johansson, 2015). According to Barkley (1997), the executive ability is impaired in ADHD, especially in persons with symptoms of overactivity. The executive ability affects the ability to receive information, multi-task, process new information, and evaluate it as a guide for action (Barkley, 1997). This means difficulties with functions such as verbal and non-verbal working memory, self-restraint, planning, and strategic thinking as well as being able to inhibit behavior (Barkley, 2010). There is also research that indicates that the reward systems in the brain are less developed in persons with ADHD, which can affect motivation and mean increased resistance to tasks that do not provide quick rewards (Volkow et al., 2011; Addicott et al., 2019).

Many people with ADHD have difficulty arriving in time for meetings and with arrangements, planning, and routines for home, family, and work (Brod et al., 2012). Sometimes they can occupy themselves with a task or activity with such enthusiasm that they have an increased risk of being burned out (Hupfeld et al., 2019). But despite this, many find it difficult to get everyday tasks done, such as paying bills and cleaning.

Situations that require multi-tasking can cause major problems for persons with ADHD and create a lot of stress, absent-mindedness, for example, driving a car (Fuermaier et al., 2017). Persons with ADHD are often described as forgetful (Brod et al., 2012). A large part of their time is spent looking for lost things. They can also forget about meetings, agreements, and commitments (Schrevel et al., 2016).

Transitional situations that involve ending one activity and starting another often cause problems for persons with ADHD. It is important for them to know in advance what is going to happen, as they have a very hard time dealing with uncertainty and ambiguity. Many also experience a lack of track sense, which creates great insecurity and a feeling of uncertainty (Storebø et al., 2019). A kind of limitlessness can also arise, and this can, for example, mean that they consume too much food and drink (Barkley & Fischer, 2011). Others describe difficulties in understanding instructions and directions because they do not have the patience to listen or read the instructions (Watters et al., 2018). In particular, persons with ADHD experience impairments in several everyday areas, including the ability to maintain social relationships, maintain employment, and live independently (Schrevel et al., 2016; Brod et al., 2012), leading to increased stress in everyday life (Hirvikoski et al., 2011; Hirvikoski et al., 2009).

7.2.2 Lifestyle Factors

A sedentary lifestyle is more common among persons with ADHD (Barkley, 2018), which involves major health risks and risk of premature death (Barkley & Fischer, 2019; Suchert et al., 2017; Quesada et al., 2018). Persons with more symptoms of ADHD may have more deficient dietary habits and use cannabis to a greater extent (Ptacek et al., 2016). ADHD is strongly linked to increased health risk behaviors such as substance abuse, varying eating habits, binge eating, and sexual risk behavior. Cognitive disabilities, psychosocial disabilities, and stress in persons with ADHD may be the causes (Schoenfelder & Kollins, 2016). ADHD is also associated with bad eating habits, eating disorders, and stomach surgeries for obesity (Hershko et al., 2018; Hershko et al., 2020; Li et al., 2020; Şahan et al., 2021). ADHD affects the possibility to treat and rehabilitate eating disorders, since persons with ADHD, for example, have poorer adherence to treatment (Testa et al., 2020). Furthermore, the association between high Internet use and Internet addiction and ADHD is well-known (Li et al., 2016). Another negative lifestyle factor is loneliness. Adult persons with **ADHD** have an increased risk of feeling lonely which strongly affects well-being and health (Stickley et al., 2017). Common among them are physical and mental limitations in the form of lack of energy, which makes it difficult to cope with everyday things. Pain is also common, which can be an obstacle to exercise (Rogers et al., 2017; Stickley et al., 2016).

ADHD is associated with low conscientiousness and lack of inhibition (Gomez & Corr, 2014). Conscientiousness refers to how much a person uses his conscience to make decisions about his own actions and their consequences for himself and others. Barkley and Fischer (2019) believe that it contributes to adults with ADHD engaging in unhealthy and life-shortening activities, such as smoking, alcohol and drug consumption, risk-taking, poor diet, sedentary, and generally unhealthy living. There are thus several different reasons for the increased risk of morbidity and premature death. ADHD is also linked to a higher risk of accidents in childhood and adulthood (Nigg, 2013), car accidents (Barkley et al., 2002; Fuermaier et al., 2017), thoughts about suicide, suicide attempts, and actual suicide (Stickley et al., 2018; Conejero et al., 2019).

7.2.2.1 Drug Use and Poor Diet

For persons with ADHD, it can be difficult to live by routines that are important to be able to maintain a good diet. They may also have difficulty feeling hungry. There is a risk that they eat too fast and too much due to lack of impulse control. Poor eating habits may include low intake of nutritious foods such as fresh fruits, vegetables, and high consumption of fats and sugars (Kjaer et al., 2017; Ptacek et al., 2016; Hershko et al., 2018; Wang et al., 2019). A side effect of drug treatment for ADHD can be decreased appetite, which may lead to a lack of sufficient energy needed to cope with life and exercise a healthy lifestyle (Storebø et al., 2018). In addition, studies show that eating disorder problems are associated with ADHD (Brunault et al., 2019). In another study, it has been shown that persons with eating disorders have a different metabolism due to genetic causes (Watson et al., 2019). This is important to keep in mind when treating ADHD (Karjalainen et al., 2016).

7.2.2.2 Alcohol and Drug Abuse

Persons with mental diagnoses smoke more than the general population (Stein et al., 2019). Adults with ADHD smoke more than other persons and start smoking earlier in adolescence (Galéra et al., 2017). One explanation may be that nicotine can temporarily alleviate ADHD symptoms, leading to persons trying to self-medicate (Potter et al., 2012). There are studies that suggest that it may be more difficult for persons with ADHD to quit nicotine, because abstinence becomes more severe and worsens the symptoms (Bidwell et al., 2014). They may therefore need much more support than others to stop using nicotine (Bidwell et al., 2018).

Another health risk is drug and alcohol abuse, which is more common than in the rest of the population. Self-medication with alcohol and other drugs can be understood as consequence of stress and adversities that ADHD symptoms cause (Odell et al., 2017). However, there may also be neurobiological or behavioral explanations for the fact that persons with ADHD have an increased risk of developing addiction (Breyer et al., 2014). With mental illness, substance abuse can be more common which means that persons with both ADHD and mental illness are particularly vulnerable. However, studies show that it is easier to treat addiction if the person is simultaneously medicated for the symptoms of ADHD (Cougle et al., 2016). Side effects from the medication, such as fatigue, effects on heart rate, and higher blood pressure, can also be an obstacle to healthy lifestyle habits, such as physical activity (Storebø et al., 2018; Westover et al., 2016).

7.2.3 Major Morbidity with Both Physical and Mental Illness

The awareness of ADHD must be prioritized as a more important public health issue, since ADHD has been linked to a nearly 13% reduction in estimated life expectancy (Barkley, 2020; Canady, 2019). ADHD is associated with a number of other medical conditions, including increased incidence of type 1 diabetes, hypothyroidism, epilepsy, obesity, fibromyalgia, pain, migraines, and difficulty sleeping (Muskens et al., 2017).

Adults person with ADHD (both men and women) had an increased risk for a greater range of physical conditions compared with adults without ADHD (eg, sleep disorders, epilepsy, dementia; and respiratory diseases such as asthma, and chronic obstructive pulmonary disease) (Du Rietz et al., 2021). In addition, ADHD is associated with a higher risk of cardiovascular disease (Callahan et al., 2021). The medication also increases the risk of cardiovascular disease (Torres-Acosta et al., 2020).

Other research shows the risk of traumatic brain injury, poorer dental health, increased tobacco, alcohol and marijuana consumption, more sedentary habits, metabolic diseases, and type 2 diabetes (Nigg, 2013; Chen et al., 2018; Zhao et al., 2019).

Persons who have ADHD are also overrepresented when it comes to mental illness. About 85% of persons with ADHD have some form of psychiatric comorbidity. They also have increased comorbidity with bipolar syndrome, schizophrenia, and borderline personality disorder (Weiner et al., 2019). Furthermore, it is more common among them in addition to their ADHD diagnosis to also be diagnosed with autism. In women with ADHD, emotional instability is more common than in women without. They also more often suffer from anxiety, depression, and stress. Antisocial personality disorder is more common in men with ADHD than in men without ADHD (Bitter et al., 2019; Solberg et al., 2018).

7.2.4 Problems with Social Relationships and Loneliness

Studies have shown that adults with ADHD have distorted self-esteem that can be derived from childhood difficulties such as social role expectations and adjustment difficulties (Krueger & Kendall, 2001). In addition, a study showed that they used destructive coping strategies such as confrontational, avoidance, and impulsive problem-solving methods (Young et al., 2008).

A cohort study from Finland showed that adults with ADHD had poorer health and more contact with health care than the general population. They also lacked close relationships and experienced more loneliness than persons without the diagnosis (Stickley et al., 2017). Many live alone without a partner and lack close friends (Bjerrum et al., 2017). Furthermore, they are often involved in interpersonal conflicts (Barkley et al., 1992).

Loneliness can lead to deteriorating lifestyle habits and to an increased risk of cardiovascular disease (Richard et al., 2017; Xia & Li, 2018). Loneliness is also associated with all types of mental illness, especially depression (Strohmeier et al., 2016; Richard et al., 2017) which may be associated with loneliness in adults with ADHD (Michielsen et al., 2015). Loneliness can be characterized by feelings of isolation and is a strong indication of mental illness that may be associated with suicidal behavior (Calati et al., 2019; Shevlin et al., 2015). This highlights the importance of efforts to reduce loneliness to mitigate these harmful health effects (Stickley & Koyanagi, 2016; Ruchkin et al., 2017).

The more additional difficulties, for example, simultaneous mental illness, the more difficult a disability naturally becomes. The core symptoms of ADHD are disabilities that have consequences in daily life, both in relationships with other persons and when it comes to making life work in a purely practical way. With increasing age, disabilities can vary, depending on how a person with ADHD is able to handle them, external changes, and increased demands from the environment (Barkley & Fischer, 2011).

7.2.5 Deteriorated Quality of Life

Living with ADHD and suffering from mental illness affects the quality of life. ADHD symptoms such as inattention, hyperactivity, and impulsivity affect many different areas of life (Adler et al., 2013). This can, for example, lead to persons with ADHD experiencing a lack of control and independence (Joseph et al., 2019), suffering from unemployment, low self-esteem (Agarwal et al., 2012; Brod et al., 2015), lack of health care and increased stigma (Ahnemark et al., 2018; Stickley et al., 2019). Many adults with ADHD have been diagnosed late in life, which affects the quality of life negatively (Ahnemark et al., 2018). Persons with ADHD experience that they are less happy than others (Stickley et al., 2018).

Quality of life is also about lifestyle habits such as the amount of physical activity (Muskens et al., 2017). Many adults with ADHD also experience a lack of close social relationships and social interactions in their daily lives (Stickley et al., 2017; Michielsen et al., 2015).

7.2.6 Combined Treatments Are Needed

There is an obvious need for effective treatments for adults with ADHD. When they do not receive treatment, the costs become high, both for the individual and for society. It is important to focus on the consequences of ADHD in everyday life in order to develop a multimodal approach to treatment, e.g., a combination of several different interventions with support (Miranda et al., 2014). Both in Sweden and in other countries, it is generally held that a combination of medication and other treatment measures is needed for optimal care and support for adults with ADHD (Kooij et al., 2010; Kooij et al., 2019). Research also indicates that it is important that they find strategies to become more independent in their work with everyday activities and that they engage in healthy life choices (Ek & Isaksson, 2013).

Drugs, especially central stimulants, are often considered the single most effective treatment, and the use of drugs for ADHD has increased for adults. Statistics show that about 30% of the adults with ADHD who were treated with the drug Methylphenidate were also treated with other medication because they also suffered from other mental illnesses. It is important to treat persons with ADHD with medication so that they can function in a social capacity in school and working life so that they do not have a reduced quality of life. Drugs alone have been shown to be an inadequate treatment of ADHD, and psychosocial interventions are important additions to treatment (Antshel et al., 2014; Young et al., 2015; Wilens et al., 2002; Torgersen et al., 2008).

Today, the recommendation for adults with ADHD and comorbidity with mental illness is individual treatment with several different treatment methods in combination, such as psychoeducation, medication, coaching, and cognitive behavioral therapy (Kooij et al., 2019). Barkley and Fischer (2019) emphasize the importance of also treating lifestyle habits for increased quality of life and longer lives. Since persons with ADHD may find it difficult to be motivated and mobilize energy to do everyday activities (Faraone et al., 2015), a lifestyle intervention with a holistic perspective may be supportive of changing lifestyle habits.

7.3 Lifestyle Interventions Are Important to Improve Life Situation

There is little research on lifestyle interventions concerning adults with ADHD. However, there are several studies on lifestyle interventions for children diagnosed with ADHD. Existing research suggests that lifestyle interventions are an important and neglected area for adults with ADHD and concomitant physical and mental illness (Weissenberger et al., 2018; Barkley et al., 2019). We also know that lifestyle interventions in the general population are effective tools for reducing cardiovascular risk factors (Sisti et al., 2018). In addition, group-based models appear to be the most widely used design for lifestyle interventions for persons with mental illness (De Rosa et al., 2017) and are effective for persons with ADHD (Kooij et al., 2019).

A meta-analytic review of the efficiency of physical activity interventions on cognition in persons with ADHD showed that physical activity is a very important lifestyle habit in order to increase cognitive ability (Tan et al., 2016). Another study showed that aerobic exercise could improve executive function and attention (Mehren et al., 2019).

Many studies have investigated whether physical activity can affect ADHD symptoms. A systematic review and meta-analysis found that physical activity could improve ADHD-related symptoms, especially inattention symptoms (Xie et al., 2021).

Furthermore, research suggests that physical exercise and fitness affect cognitive functions in adults (Erickson et al., 2011; Den Ouden et al., 2018) and may therefore be a potential protective factor for adults with ADHD (Mehren et al., 2019; Firth et al., 2018). In addition, physical exercise interventions have been shown to effectively reduce the weight of obese adults both without and with an ADHD diagnosis (Quesada et al., 2018; Ruotsalainen et al., 2015). Studies also suggest that cognitive functions improve and symptoms of depression decrease (Wegner et al., 2014; Tan et al., 2016). Physical exercise affects the dopamine system, which may also play an important role in the biological explanation of ADHD and unhealthy lifestyle habits (Barkley et al., 2019). In addition, dopamine plays a role in depression and obesity (van de Giessen et al., 2014).

There are a number of psychosocial interventional treatments for adults with ADHD that are designed to improve daily life rather than reduce symptoms. Psychoeducation is about increasing patients' knowledge of how ADHD symptoms affect their lives (Hirvikoski et al., 2017). Psychoeducation should be the first step in the treatment of ADHD along with medication (Kooij et al., 2019). Cognitive behavioral therapy (CBT) is a form of therapy that has been shown to work well for adults with ADHD, although the studies may be of low quality (Lopez et al., 2018). In CBT, the basic idea is to change thought and behavior patterns in order for patients to be better able to handle emotional distress (Lopez et al., 2018; Vidal et al., 2013). Other areas for lifestyle interventions are workplace support and relationship therapies (Mao et al., 2011). Interventions with mindfulness have also proven promising in terms of support for adults with ADHD (Poissant et al., 2019). One area that there is little research on is Internet-based interventions that can be an addition to other treatments (Sehlin et al., 2018; Pettersson et al., 2017). Interventions that contain physical activity appear promising for cognitive functions (Tan et al., 2016, Christiansen et al., 2019, Ashdown-Franks et al., 2020, Suarez-Manzano et al., 2018.

Adults with mental illness are in some cases treated with lifestyle interventions, especially persons with schizophrenia and depression. The treatment is focused on cardiovascular risk factors and includes physical activity, dietary advice, and support to quit smoking (Naslund et al., 2017, Opie et al., 2015, Bort-Roig et al., 2019). Lifestyle interventions with a lot of physical activity have shown positive results for weight loss, reduced symptoms of depression, and reduced risk of developing metabolic syndromes (Naslund et al., 2015; Bersani et al., 2017; Fornaro et al., 2017). Interventions with cardio training had a small effect on cognitive functions (Tan et al., 2016). Interventions with physical activity and changed dietary habits also indicate improved quality of life (Hjorth et al., 2017). A nurse-led lifestyle group program for people with severe mental illness included health education, cognitive support, and individual lifestyle changes. The program gave small health improvements in the form of reduced waist circumference and improved cognitive performance (Rönngren et al., 2018a, b).

The work teams involved in lifestyle interventions were mostly composed of the same professional roles, such as nurses, dietitians, and physiotherapists. There were differences in the format (individual or group), and whether the training was combined with MC (motivational conversation) or other problem-solving techniques. Regarding how long the intervention should last, some research indicates that interventions that last up to 2 years show better results regarding changed lifestyle habits (De Rosa et al., 2017). Other studies show that it probably takes longer to achieve long-term results (Blomqvist et al., 2019). For persons with ADHD, the core symptoms can sometimes be an obstacle in traditional health care and can lead to reduced adherence to treatment. An intervention study by Biederman et al. (2019) found increased compliance and commitment to drug treatment through supportive text messaging.

Vitamin D supplementation as adjunctive therapy to methylphenidate appeared to reduce ADHD symptoms. However, considering the general lack of strong evidence, more studies are needed to determine the efficiency (Gan et al., 2019). Antioxidants and omega-3 have been shown to stabilize ADHD symptoms in some persons (Moghadas et al., 2019).

7.3.1 Experiences of Lifestyle Interventions

Participating in a lifestyle intervention has previously been shown to give participants a sense of security because they gain knowledge about their neuropsychiatric problems (Sehlin et al., 2018). But tools that support changes in healthy lifestyles must be adapted individually, and it is important to strengthen self-confidence using small steps (Lundstrom et al., 2017). Participants with ADHD in a lifestyle program (which was about quitting smoking) also expressed that it was important to highlight the specific symptoms of ADHD because the symptoms proved to be an important component of success (Liebrenz et al., 2016).

Being part of a social context is also important (Graham et al., 2014). In addition, lifestyle interventions for persons with mental illness and for persons with ADHD should aid participants to develop their ability to manage varying moods and motivation to improve, for example, their eating and exercise habits (Yarborough, 2016; Cortese & Tessari, 2017). Information about risk activities, potential gains, and losses is important, as well as individual positive feedback (Graziano et al., 2015; Richards & Rahm Hallberg, 2015).

7.3.1.1 Social Support and Motivation Are Needed

Other diagnoses such as mood swings, anxiety, and emotional instability can be treated at the same time as the actual symptoms of ADHD. Drug and alcohol abuse should be stabilized before starting treatment but can also be treated at the same time as ADHD problems (Kooij et al., 2019).

Practical and social support from healthcare professionals is important both to improve daily life and to implement physical health routines for persons with ADHD (cf. Leahy, 2018; Laugesen et al., 2017; Moen et al., 2014; Jain et al., 2017). An obstacle to a healthier lifestyle in persons with ADHD and mental illness can be a lack of knowledge about health issues in both patients and relatives (Kooij et al., 2019; Hirvikoski et al., 2017). Hirvikoski et al. (2017) emphasize the importance of collaborating with relatives in health education. There can also be various obstacles to successful group education. For example, it may be that the participants receive too much information and too little time for reflection. Studies show that health promotion work is successful when healthcare professionals leave the expert role and engage participants in health discussions in small groups (Hempler et al., 2018).

There is a lack of research on motivational conversation (MI) for persons with ADHD, but it can be an effective method in combination with behavioral therapy (Sibley et al., 2016). Ortiz and Sjölund (2015) have combined clarifying pedagogy and motivational conversations to compensate for the participants' short attention span. This means less talk and more visual communication techniques that are better adapted to human cognitive ability. The importance of healthy eating and physical activity should be reiterated over time (Ortiz & Sjölund, 2015). Other studies suggest that MI with a focus on lifestyle habits improves both mental and general health in persons with mental illness (De Rosa et al., 2017), and the way to motivate is the same for persons with mental illness and for those without (Farholm & Sørensen, 2016).

MI techniques focus on the individuals' own strengths and opinions about risky health behaviors, such as smoking, lack of physical activity, and alcohol consumption (Stonerock & Blumenthal, 2017). A study by Sibley et al. (2016) showed that the use of MI was beneficial in helping adolescents with ADHD to organize and plan. MI can thus be an important tool for getting started with healthy lifestyle habits.

7.3.2 Need for More Health-Promoting Lifestyle Interventions for Persons with ADHD

Since ADHD is today seen as a chronic diagnosis that lasts a lifetime, new health-promoting strategies are needed (Barkley & Fischer, 2019; Schoenfelder & Kollins, 2016). Barkley and Fischer (2019) believe that life expectancy is, after all, possible to affect because improving lifestyle habits can improve quality of life and prolong life. Society and health care have a responsibility to collaborate, develop, and implement strategies for health promotion measures for persons with ADHD (Kooij et al., 2019). It is important that health care takes the lead and organize and implement strategies to promote the quality of life of persons with ADHD (Antai-Otong & Zimmerman, 2016; Moen et al., 2014; Adamou et al., 2016). In particular, nurses are trained and prepared for this work (Antai-Otong & Zimmerman, 2016; Culpepper & Fried, 2013).

In recent years, much research around the world has focused on physical health interventions in adults with mental illness (Naslund et al., 2016; Naslund et al., 2017), but little research is about lifestyle interventions for adults with ADHD. There is, however, research on lifestyle interventions for persons with mental illness, but there is no research on adapted lifestyle interventions that simultaneously focus on both physical, mental, and social health for adults with ADHD (Schoenfelder & Kollins, 2016). In addition, a more practical method is needed for lifestyle interventions that can be easily implemented in health care.

Lifestyle habits are defined as individual everyday activities that promote health. The focus here is on the diet, social relationships, and exercise that respect the body's signals and have a balance between exercise and recovery. The definition of lifestyle habits is specific behaviors in everyday activities that individuals themselves can influence, such as physical activity, diet, smoking, and alcohol use. In Sweden, for example, physical activity is prescribed on prescription to promote healthy lifestyle habits. Patients formulate goals that are followed up by healthcare professionals (Onerup et al., 2019). Lifestyle changes among adults with ADHD can help increase their life expectancy (Barkley & Fischer, 2019), for example, by reducing the impact of obesity, quitting smoking, reducing alcohol consumption, and improving diet, sleep, and exercise. Even those who are already affected by a chronic illness can improve their physical and mental health through healthier lifestyles (Roberts et al., 2017).

It is common for adults with ADHD to have lower self-esteem and low belief in their own abilities due to negative experiences in life (Newark et al., 2016). This can be an obstacle in care and lead to poorer health, especially in mental and physical comorbidity that is common in ADHD. But with health education, persons can gain knowledge that gives them better access to health care and helps in making appropriate health decisions (Ringsberg, 2014). Such knowledge is sometimes called health literacy. According to WHO (2022), health literacy is defined as the cognitive and social skills that determine the motivation and ability of individuals to access, understand, and use information in a way that promotes and maintains good health. If adults with ADHD have access to health information and can use it effectively, it will be crucial for their self-confidence (Hirvikoski et al., 2017; Kooij et al., 2019). To achieve this, interaction and participation are important (WHO, 2022). Adults with ADHD who have been diagnosed late in life and suffer from physical and mental illness have an increased risk of reduced quality of life and shortened life expectancy (Katzman et al., 2017; Barkley & Fischer, 2018). In a study by Aaby et al. (2017) conducted in the general population, it was found that health information and dedicated care were associated with healthier lifestyle habits.

7.3.2.1 Interpersonal Relationships Affect Health

The interpersonal nursing theory of Peplau (1997) has been used in the development of lifestyle intervention program for adults with ADHD. The core of Peplau's theory is interpersonal relationships, and the most important relationships consist of supportive interactions between the nurse and people with ADHD and concomitant ill health. Peplau believes that the creation of a relationship is unique and is important for achieving health. Both verbal and non-verbal communication form the basis for how the relationship develops. This perspective on health is recognized in Kattie Eriksson's theory (1992). Eriksson (1992) sees health as a driving force that is important to promote, and that it is relationships between fellow human beings that create opportunities and conditions for health. A basic precondition for health from these perspectives is an approach based on compassion, respect, and non-judgment (Peplau, 1997). Rehabilitation and nursing should be seen as a process and the nurse's role can be, for example, as a teacher, resource person, counselor, and/or leader (Peplau, 1992). In order to promote development toward increased maturity, the nurse should identify which step in the learning process and which level of competence the person has achieved and be sympathetic in this situation (Peplau, 1988).

Based on Peplau's perspective on health promotion in the relationship between the person leading the intervention and the participant Peplau (1988, 1997), the focus is on two roles in a lifestyle intervention: the group leader and the participant. The group leader's areas of responsibility include promoting health, preventing disease, restoring health, and relieving suffering (Eriksson, 1992). The group leader's approach should be health-promoting, which means strengthening and encouraging people to take responsibility for their own health and illness but also to support people's health development and motivation to change, for example, lifestyle habits (Antai-Otong & Zimmerman, 2016). When it comes to lifestyle change, the relationship and interaction are important and it is about mutual trust and confidence in the encounter (Antai-Otong & Zimmerman, 2016; Strandås & Bondas, 2018). Through increased knowledge of, for example, healthy lifestyles and a belief in their own ability to change, the patient can feel empowerment (Ringdal et al., 2017; van Berkel et al., 2015). Many adults with ADHD have waited a long time for their diagnosis, which has led to a lot of stress, anxiety, and depression. They risk being subjected to stigma in the form of prejudice and discrimination, which also could lead to self-stigmatization (Masuch et al., 2019) and may prevent them from seeking care. It is therefore important that the group leader tries to provide support through communication and by channeling and handling anxiety, so that the anxiety can be kept at a manageable level (Peplau, 1988). High anxiety levels lead to reduced ability for problem-solving and learning. Adults with ADHD have reduced quality of living conditions in several different areas of life due to lack of support.

7.3.3 A Nurse-Led Lifestyle Intervention

A nurse-led lifestyle intervention was performed with 49 adult persons with ADHD. The lifestyle program has the basic components of interpersonal relationships, health education, and cognitive support. The lifestyle program for the group provided support for individual lifestyle changes in persons with ADHD in terms of physical, mental, social health, and increased health knowledge (Björk et al., 2021; Björk et al., 2020).

7.3.3.1 The Theoretical Basis of the Intervention

Interpersonal Relationships

In a recent study (Björk et al., 2020), those with ADHD describe that their suffering is mostly about the experience of loneliness due to both the diagnosis of ADHD and the mental illness. They experienced loneliness in relation to family and friends but also in the encounter with health care. Participants expressed that they experienced well-being once they were diagnosed and were able to have social, supportive relationships. The interviewees did not feel that the medical staff listened to them. They felt misunderstood and expressed feelings of powerlessness and humiliation. It affected self-esteem and created the feeling that they had failed in their lives. They also expressed that they experienced well-being through supportive relationships that helped them recover. Receiving a diagnosis was important for well-being. Even physical activities, daily activities, such as going to work, could alleviate anxiety and also give improved self-esteem.

Peplau also describes that the therapeutic relationship between a person and healthcare staff involves four phases: orientation, identification, exploitation, and resolution. Below is a description of how these phases develop during the work with lifestyle changes, in accordance with Peplau. In the first phase, which is called the orientation phase, a trusting relationship is built between group participants and group leaders. In this sensitive first phase (where no one knows anyone else), any unhealthy lifestyle habits are identified for each participant.

In the next phase, the identification phase, appropriate individual healthy lifestyle changes are selected. The group members express some individual health problems that they would like to change. Here begins a process where the group and the group leader work together toward the goal to increase motivation. In this phase, the group leader supports behavioral changes, regardless of which they are. In this phase of managing their own health goals, participants can experience a sense of belonging.

In the third phase, the exploitation phase, individual methods are taught. Here the progress is reflected upon and summarized. To support the independence of the group members, cognitive support is used, such as schedules and reminders.

The last phase, the resolution phase, occurs after the other phases have been successfully completed. In the resolution phase, new health goals are introduced and lifestyle changes are implemented (Peplau, 1988).

Health Education and Health Information

An important part of the lifestyle intervention was education and discussions about health. The content of the health education and health discussions was established during the first ten meetings but developed over time. The last eight meetings were designed according to the participants' initiatives and wishes. MI was used as a health counseling technique to increase one's own motivation to change behavior. With the help of MI, it was possible to explore ambivalence and provide strategies for developing individual lifestyle changes, for example, to minimize alcohol consumption or quit smoking (Miller & Rollnick, 2013). In this intervention, the specially developed MI technique for ADHD and autism was used according to Ortiz and Sjölund (2015).

Individual Support

At each group training, each group participant received an individually adapted nursing plan with the goal of attaining a healthy lifestyle. For example, it could be about walking 30 minutes every day or starting to walk around your own house. The participants could receive reminders through text messages from the group leader but were also encouraged by the other group participants. It could also be to cook a healthy meal during the week. The group leaders were available by telephone as support between the group trainings. The nursing plan was followed up at the next meeting.

Each session included educational components such as health knowledge, healthy eating, and physical activity. Other areas were various mental illnesses and physical illnesses, various treatment options not only to deal with problematic symptoms such as anxiety and insomnia but also to develop healthy lifestyle habits to prevent illness.

An important component of the health discussion was that the participants in the group shared knowledge, experiences, and strategies for managing health or managing symptoms of diseases. Participants also did practical exercises, such as light gymnastics and yoga, swimming, walking, and strength training. Some of the participants also trained together both without and with the group leader between group sessions. Each session started with a relaxation exercise and ended with concluding reflections.

Social and Practical Support

Participants received individually adapted cognitive support for lifestyle changes by group leaders. The cognitive support included, for example, reminders (text messages), schedules, phone calls but also walks, and other shared exercises. In addition to the cognitive support, all participants received activity diaries where it was intended that they could register physical exercise and diet. They also received a plan for lifestyle habits and follow-up. There were blank lines in the activity diary where participants could record emotional and physical experiences. All participants received pedometers at the beginning of the intervention.

In intervention, the experiences of adults with ADHD with mental illness were examined. Participants' experiences of what it is like to live with ADHD and their experiences of health and suffering were studied. This was done to capture experiences that could add information to develop and design a lifestyle intervention aimed at people with ADHD with concomitant mental illness. Interviewees described both suffering and well-being in their lives with ADHD. The worst part of the suffering was the experience of loneliness. They felt alone in private relationships, in supportive relationships with healthcare persons, and just because of having an ADHD diagnosis. They experienced a sense of well-being once they received their correct diagnosis but equally by supportive social relationships. Therefore, it was concluded that a group lifestyle intervention would be effective for this group of people.

Respondents described severe suffering throughout life, from children to adults. They suffer in all parts of daily life and have problems with school or work, as well as in relationships with family, friends, and colleagues. This leads to them feeling different, which has affected their self-esteem negatively. They expressed sadness, anger, or feelings of injustice, guilt, and shame. Some described using avoidance strategies such as isolation, which led to increased loneliness. Some even expressed suicide thoughts and that life was so difficult to live and comprehend that they had tried to take their own lives already as children.

The respondents expressed pain in connection with diseases and their disability (ADHD and mental illness)—physical, psychological, and existential pain. They suffered from insomnia, forgetfulness, nail-biting, and depression. They had great difficulty in achieving order in daily life and in planning, such as planning meals or bedtime, proper medication, and physical activity. They expressed that they felt worthless and feared suffering from physical illnesses, loneliness, and decreased appetite for life.

They experienced suffering in connection with care and had suffered in their medical history, when they struggled to get an ADHD diagnosis. Several described being treated for a variety of psychiatric illnesses before receiving a correct diagnose. They did not feel that the medical staff listened to them. They felt misunderstood and expressed feelings of powerlessness. It affected self-esteem and gave feelings of having a failed life.

Respondents experienced well-being through supportive relationships that helped them recover. Physical activities and daily activities at work could alleviate anxiety and provide improved self-esteem. When they received their ADHD diagnosis, it also provided well-being in the form of satisfaction.

Based on the life stories, the participants' needs were interpreted, but at the same time, their own resources developed. This led to the intervention consisting of three main components: relationship, education, and support (as the previous studies showed). Based on the life stories, order in daily life, support, and motivational strategies was identified. Therefore, for example, mobile apps, activity diaries, schedules, and reminders were introduced to increase physical activity. Other identified problems were loneliness and therefore a common platform was used, WhatsApp, where participants could discuss and support each other and where even the group leaders were available at all times. Joint group meetings were introduced to build relationships and provide support and increased knowledge about managing everyday life.

Other studies described where people with a diagnosis of ADHD were compared to a group without a diagnosis of ADHD. The study described the differences in health, lifestyle habits, and fitness between the general population and persons with ADHD (Björk et al., 2018). The results were based on questionnaires and physical tests based on the LIV concept, which provided information on physical and mental health, lifestyle habits, and fitness.

The results indicated that adults with ADHD have a higher risk of deteriorating health, with an unhealthy lifestyle, and with less regular physical activity. One explanation for the differences may be due to socio-economic factors, such as education, sick leave, and income. The study clarified the participants' need for improved physical, mental, and social health. Another important resource for planning the intervention emerged. The ADHD group was not in worse condition than the comparison group. Due to the health results of the study, great emphasis was placed on diet and physical activity in the intervention. The results from the program showed that adults with ADHD are at higher risk for poorer health, physically, mentally, and socially. They have more unhealthy lifestyles with less regular physical activity than people without ADHD.

7.4 Conclusion

Living with ADHD means having a complex health situation with cognitive disabilities, suffering in daily life, and limitations in health physically, mentally, and socially. At the same time, people with ADHD have enormous resources to improve their lifestyle and to support others with ADHD for improved health. Research on lifestyle programs for adults with ADHD is deficient, and more studies on lifestyle programs with a longer follow-up period are needed. Furthermore, research is needed on experiences regarding participation in individualized lifestyle programs and factors that affect health. There is some research that supports the idea that continuous health-promoting lifestyle programs based on interpersonal relationships, health education, and health discussions as well as cognitive support can be useful for lifestyle changes among people with ADHD. Participating in group discussions and building relationships in a supportive community has proven successful in developing new coping strategies to reconcile suffering and achieve health. Fellowship with others in similar situations is most important in reducing suffering. The community of other people with ADHD played a role in the extent to which people with ADHD managed to change their own lifestyles.

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Teacher Knowledge of ADHD in Children

8

Charlotte W. Greenway

8.1 Introduction

Prevalence rates of attention-deficit/hyperactivity disorder (ADHD) are difficult to ascertain due to the different methods used to obtain them. However, estimated figures for worldwide prevalence in children and adolescents (aged <18 years) stand at 2.2% (Fayyad et al., 2017). This figure may not appear to be a large percentage, but for classrooms in many countries, this could mean as many as one in every 20 children. The symptoms of ADHD can have significant educational implications for students since they often lack the skills required for classroom settings (Barkley, 2015). The inattention symptoms associated with ADHD mean that children have difficulties completing tasks, sustaining attention and following instructions. The symptoms of hyperactivity and impulsivity can lead to poor impulse control, fidgeting, excessive talking and an inability to ignore distractions (American Psychiatric Association, 2013). The consequences of the abovementioned issues include an elevated risk of learning difficulties, poor attendance and the likelihood of repeating a year or dropping out of school (Fleming et al., 2017; Fried et al., 2016).

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8.2 Impact of ADHD in the Classroom

Research has consistently documented that children with ADHD show persistent hyperactivity and inattention, poor educational outcomes, and disruptive and high-risk behaviour (Faraone et al., 2015; Dalsgaard et al., 2015). Poor educational outcomes are often attributable to limited concentration, inattention and hyperactivity (Corder et al., 2015; Galéra et al., 2009; Sijtsema et al., 2014), poor attendance and off-task behaviour (Fleming et al., 2017; Barkley, 2015). Students with ADHD tend to have a lower grade point average (Keilow et al., 2018) and perform lower in reading, writing, and math than those without the disorder (Bussing et al., 2012; Costa et al., 2014). Evidence also suggests that the inattentive aspects of ADHD have the most significant effect on academic performance (Santosh & Rachana, 2019; Schmiedeler & Schneider, 2014). This results from failing to keep up in lessons, inability to complete work and demonstrate attention to detail, or poor organisational skills (Barkley, 2015). Research has also reported that teachers often perceive children with ADHD as more stressful to teach than children without the disorder. This is because the hyperactive/impulsive behaviours (inability to sit for long periods, fidgeting, non-stop talking, blurting out answers) often disrupt the teaching process and classroom environment, leading to a loss of satisfaction in

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teaching, self-doubt and a need for extra support in the classroom (Greene et al., 2002; Hong, 2008).

The behaviours associated with ADHD also affect peer relationships. For example, infringing on personal space and interrupting others often leads to frustration, bullying, social exclusion and peer rejection (McQuade & Hoza, 2015; Barkley, 2015; Hughes & Zhang, 2007). In addition, children with ADHD are not usually seen as fun in play situations. They often want to control the rules of the game, and since they have difficulty expressing emotions and have limited self-control, play can lead to aggression, exclusion and peer rejection. Children who face peer rejection are more likely to be excluded from social activities that provide crucial opportunities to develop friendships and refine the social skills needed to navigate school life (Parker et al., 2006). Literature shows that children with ADHD are four times more likely to be rejected by their peers and twice as likely to have no friends in their classroom or lose them over time compared to typically developing children (Hoza et al., 2005; Normand et al., 2013). Over time, peer rejection can lead to peer victimisation (Efron et al., 2021) and internalising problems (Reijntjes et al., 2010) and an elevated risk of learning difficulties and future psychosocial issues (DuPaul & Stoner, 2014).

The symptoms of ADHD also affect outcomes such as school engagement. For example, in one study (Portilla et al., 2014), children aged 4–6 years with high levels of inattention and impulsivity at the start of term predicted lower school engagement at the end of the school year. In the same study, high levels of inattention and impulsivity led to poor student–teacher relationships regarding increased conflict and decreased closeness. Within student–teacher relationships, closeness depicts warmth and positive affect, whereas conflict depicts negativity within the relationship and lacks rapport. Negative teacher–student relationships, marked by conflict, are particularly damaging to students, more damaging than a lack of closeness (Murray & Murray, 2004; Rudasill et al., 2013). Negative student–teacher relationships can lead to stress, anxiety and aggression in students (Hashemi, 2011; Alnuzaili & Uddin, 2020). Conversely, positive relationships with teachers can help to protect students at risk of school failure (O'Connor et al., 2011) since they can influence learning outcomes (Xie & Derakhshan, 2021), student motivation (Zheng, 2021) and academic success (Lammers et al., 2017). The disruptive nature of ADHD can often exacerbate negativity and conflict in student–teacher relationships, resulting in demotivation and self-deprecation in children with ADHD (Kendall, 2016) and increased teacher stress (Greene et al., 2002).

In a later longitudinal study in Melbourne, Rushton et al. (2020) examined the effect of ADHD symptoms on children's emotional engagement with school. They also explored student–teacher closeness and conflict as mediating variables for 498 primary school children. The authors obtained baseline measurements of ADHD symptom severity and emotional engagement (mean age of 7.3 years). Measurements were also taken at 18 months (mean age of 8.9 years), at 36 months (mean age of 10.5 years) and at 54 months (mean age of 12 years). Student–teacher relationships were assessed using the teacher report on the Student–Teacher Relationship Scale (STRS: Pianta, 2001) at age 10. Unlike most research on the impact of ADHD on school outcomes, this study captures the child's voice by asking children with ADHD about their emotional engagement with school. The findings revealed that the more ADHD symptoms children displayed in early primary school, the more conflict teachers reported in their relationships with those students in middle primary school, which was associated with lower student-reported emotional engagement with school. However, ADHD symptom severity did not predict student–teacher closeness, and student–teacher closeness did not predict emotional engagement with school. The authors suggest that children who experience many ADHD symptoms experience more disruption to their learning and the classroom environment. This often leads to negative interactions with teachers, as they try to support and deal with off-task or disruptive behaviours. Thus, these conflictual interactions harm student–teacher relationships, impacting students' feelings about school and their learning. Although the authors conclude that ADHD symptom severity is a significant risk factor for lower emotional engagement in school and negative student–teacher relationships, their study has limitations. For example, school engagement and student–teacher relationships are influenced by factors not considered in their research, such as peer relationships and family circumstances, teacher experience and training and attitudes towards students with ADHD. Despite these limitations, the study raises important questions for schools and teachers regarding the need to improve student engagement and develop skills to support children with ADHD and reduce conflict in the student–teacher relationship.

The lack of knowledge and understanding of the disorder is underpinning many of the issues raised above. For example, teachers who do not understand the poor educational outcomes resulting from memory problems, weak organisational skills and difficulty seeing tasks through will fail to provide appropriate support and strategies to enable students to succeed academically. In addition, if children feel disengaged at school and think they cannot speak with the teacher about their concerns, these individuals are unlikely to succeed academically, and student–teacher relationships are likely to suffer.

8.3 Importance of the Teacher's Role for Children with ADHD

Teachers are under increasing pressure to meet the age-related learning objectives laid out by the curriculum and respective educational departments while providing an inclusive education for all. However, challenges occur when the progress and performance of children are affected by hyperactive or disruptive behaviours (Burton et al., 2009), and teachers feel overwhelmed and are ill-equipped to tackle these behaviours (Scanlon & Barnes-Holmes, 2013). The literature shows teachers often feel underprepared and that a significant number of them have gaps in their knowledge of ADHD, which can affect how they behave towards children with the disorder and how they implement and evaluate interventions in the classroom. Ohan et al. (2008) demonstrate how knowledge levels impact teacher behaviour towards ADHD. Here teachers were asked to rate their likely reactions to ten vignettes describing children with inattentive and hyperactive-impulsive behaviour, with and without accompanying disruptive behaviours. Following each vignette, teachers were asked to make nine ratings on 9-point Likert scales reflecting important areas of teacher behaviour towards and perceptions of children with ADHD. These included the likelihood of seeking assessment and perceived benefit of professional service seeking, perceived benefit of ADHD treatments and expectations of teaching a child with ADHD. The results revealed that high knowledge levels meant that teachers were more likely to report that children with ADHD would benefit from professional services and that they would encourage parents to seek out these services. The finding that those with low knowledge levels were less likely to do so has severe repercussions for those with ADHD. If teachers are not inclined to seek professional help for those with ADHD or fail to encourage parents to do so, the child will not have access to the much-needed resources and support. More worryingly, their actions may incorrectly lead parents to think that there are no issues with their child's education which can affect any future need for help and the trust required for a positive teacher-parent relationship.

Ohan's findings also have implications for referrals and decisions about subsequent behavioural interventions. Teachers are often the first to notice the symptoms of ADHD. Since teachers work closely with pupils daily, they provide valuable information about ADHD behaviours and a pupil's history. A teacher's initial concerns and documented descriptions of behaviours and performance are crucial to informing referral processes (Anderson et al., 2017). However, due to inadequate knowledge, teachers are not always able to recognise the symptoms of the condition (Bailey & Owens, 2005) and consequently may overestimate or underestimate the prevalence of ADHD in their classrooms (Glass & Wegar, 2000; Havey et al., 2005; Sciutto & Eisenberg, 2007). For teachers to recognise children who may need a referral for diagnosis, implement appropriate interventions and monitor their effectiveness, teachers must have a sound knowledge of the disorder so that children receive the necessary treatment and support required to optimise school-related outcomes.

8.4 Teacher Knowledge

Knowledge is defined as 'having information and skills that are the product of experience and/or education' (Perold et al., 2010, p. 460). Teachers learn about ADHD and how to meet the diverse range of children's needs either during their pre-service training or via ongoing professional development programmes. However, in many of the reviews that examine approaches to teacher training (Australia, USA and Canada: Singh & Squires, 2014; UK: Stewart, 2006), the majority of pre-service teachers did not receive training in ADHD, and those that did report that it was somewhat inadequate. Furthermore, limited knowledge training may lead to negative perceptions and interactions with children with ADHD and negative attitudes towards the disorder, which could negatively affect the experiences of both child and teacher (Mulholland et al., 2015).

Much of the literature investigating teacher knowledge of ADHD asks questions assessing their knowledge of symptoms, prevalence, aetiology, prognosis and treatments. For example, symptom questions may include 'ADHD children often fidget or squirm in their seats' and 'children with ADHD are easily distracted'; prevalence questions may include 'most estimates suggest that ADHD occurs in approximately 15% of school-age children'; aetiology – 'ADHD can be inherited'; prognosis questions may include 'most ADHD children "outgrow" their symptoms by the onset of puberty and subsequently function normally in adulthood'; and for treatments, 'special diets (e.g. reduced sugar, wheat free, lactose-free, additive-free) are an effective treatment for ADHD'. Generally, teachers are asked to agree, disagree or answer true, false, or don't know, depending on the scale's requirements (example questions above are taken from the Scale for ADHD-specific Knowledge (SASA) – Mulholland, 2016, and the Knowledge of Attention Deficit Disorders Scale (KADDS) – Sciutto et al., 2000).

Many studies have investigated teacher knowledge of ADHD over the last few decades. The studies have shown inconsistencies in teacher knowledge about the characteristics, aetiology, prognosis and treatment of ADHD, with some studies reporting the greatest knowledge of symptoms (Anderson et al., 2012; Shroff et al., 2017) and others for treatments (Mulholland et al., 2015; Amiri et al., 2017). Similarly, some studies have reported that knowledge is the poorest for diagnosis and assessment (Mulholland et al., 2015; Topkin & Roman, 2015), while others report the poorest knowledge for the aetiology of ADHD (Stampoltzis & Antonopoulou, 2013; Amiri et al., 2017).

In a systematic review by Mohr-Jensen et al. (2019), teacher knowledge scores varied considerably for symptoms, prognosis and treatments. The authors reported that teachers have adequate knowledge of the symptoms of ADHD. For example, 70–100% of teachers reported knowing that children with ADHD have attention difficulties, and 88–99% recognised that they are easily distracted. A further 85–95% knew that children with ADHD can fidget and have difficulty sitting still. For impulsivity, 79–87% acknowledged that children with ADHD can act impulsively. Finally, 85–93% disagreed with the statement that children with ADHD can do better if only they tried harder. The authors also explored teacher knowledge of the prognosis of ADHD. From the limited studies available, 7–82% of teachers reported knowing that ADHD continued into adulthood. Only in one study did teachers acknowledge the relationship between ADHD and poor educational attainment (71% of teachers), which is surprising since this appears to be well-established in the literature. In two further studies, 62–65% recognised ADHD as a risk factor for developing psychiatric disorders. Therefore, on the whole, teachers were less knowledgeable regarding the prognosis of ADHD, but in their defence, this area of knowledge is underinvestigated.

The review by Mohr-Jensen et al. also highlighted the differences in teacher knowledge across countries. For example, 43–86% of US studies acknowledged the genetic and hereditability of ADHD. Whereas European and Australian samples ranged between 26% and 74%. Teachers' acknowledgement of a genetic basis for ADHD among non-Western countries such as Saudi Arabia was much lower at 13–46%. When teachers were asked about their beliefs surrounding ADHD, 20–97% rejected the statement that ADHD is caused by poor parenting, caused by stress and chaos at home (35–86%), with 15–100% rejecting the statement that ADHD is caused by eating sugar/food additives. The authors also reported that some teachers believe that psychosocial factors cause ADHD. The final selection of questions examined knowledge of the treatments of ADHD. Here, 9–86% of teachers thought medicine to be an effective treatment for ADHD, and 8–40% understood that stimulants were the most common type of drug used in ADHD treatment, but 58–96% knew that medication is not the only treatment for ADHD. 63–95% understood that even when medications have been prescribed, there is still a need for psychosocial and classroom interventions, and 14–90% knew that medication does not cure ADHD. Mohr-Jensen et al. conclude that the small sample sizes within many of the studies reviewed limit the representativeness of teachers. Nevertheless, this review appears to represent the current status of teacher knowledge of ADHD, with much of the research presenting low to adequate knowledge levels.

8.5 Consequences of Poor Teacher Knowledge

For teachers to provide the best support and education to students with ADHD, they require in-depth knowledge of the different elements of the disorder stated above. However, the literature suggests that teachers have adequate knowledge at best (Alkahtani, 2013; Greenway & Rees Edwards, 2020; Mulholland et al., 2015), the consequences of which hampers teachers' ability to provide sufficient support for those with the disorder (Latouche & Gascoigne, 2019). Furthermore, limited or inaccurate knowledge of ADHD leads to misconceptions and inaccurate beliefs about the disorder, negative attitudes, stigma and inappropriate use of classroom interventions and punishment strategies (Sciutto et al., 2016; Greenway & Rees Edwards, 2020; Mulholland et al., 2015; Fuermaier et al., 2014; Gaastra et al., 2016; Blotnicky-Gallant et al., 2015).

Many teachers feel unprepared to teach a student with ADHD when they have limited knowledge of the disorder (Murphy, 2014). This unpreparedness leads to teachers experiencing more stress than teachers without a student with ADHD. Such stress can lead to an increase in reprimands or punitive actions towards those with ADHD. These interactions are noticed by peers and are likely to negatively affect peer relationships and the self-esteem of those with ADHD (Mrug et al., 2012). In addition, punitive actions are likely to invoke an impulsive response from the student with ADHD, often leading to further negative feedback and reprimands. This cycle of behaviour is expected to lead to negative attitudes from teachers and peers, so breaking it through teachers' understanding of ADHD should encourage the use of appropriate strategies (rather than punitive actions and reprimands), improving student–teacher relationships and reactive behaviours. In addition, this behaviour change will show that the student is accepted in the classroom by their teachers and thus more likely to be accepted by their peers (Bradshaw & Kamal, 2013).

In recent years, considerable interest has been directed towards how knowledge affects attitudes towards ADHD. Attitudes refer to the evaluation of people, events, objects, or issues as either favourable or unfavourable (Eagly & Chaiken, 1993). A teacher's attitude, consciously or unconsciously, affects students' interest in learning and subsequent academic performance (Omolara &

Adebukola, 2015). For many teachers, attitudes represent their reactions to their experiences, combined with knowledge of the disorder, teaching experience, pre-service training and student–teacher relationships (Wubbels et al., 2014). Attitudes will affect how they behave towards students, and negative attitudes can result in adverse outcomes for students (Lee & Witruk, 2013). Teachers with positive attitudes can cope with daily challenges and have a positive outlook, which is vital for shaping classroom management and student success (Omolara & Adebukola, 2015; Bolhuis & Voeten, 2004; Blotnicky-Gallant et al., 2015). Teachers who display negative attitudes may appear unapproachable, leading to low student engagement, poor behaviour and academic performance (Steiner et al., 2014; Rush & Harrison, 2008). For those with ADHD, teacher attitudes have a powerful impact on future achievements, social relationships and self-esteem (Barkley, 2015; Loe & Feldman, 2007). Teachers often find managing the behaviour of students with ADHD difficult, and the disruption to the classroom has negative consequences on their attitudes (Ewe, 2019). Exacerbated by inadequate knowledge and inconsistent evidence surrounding its causes and contributors (Youssef et al., 2015; Dryer et al., 2013) is likely to increase teacher uncertainty and ambivalence towards the disorder and about teaching children with ADHD (Anderson et al., 2012). With such uncertainty and the challenges that a child with ADHD may present, it is not surprising that teacher attitudes towards children with ADHD can be negative.

Evidence has shown that teachers with negative attitudes towards ADHD feel challenged by overactive children (Burkman, 2012) and unprepared when dealing with these students (Murphy, 2014). For example, when presented with a description of a child with ADHD, teachers in a study by Batzle et al. (2010) viewed the child significantly less favourably than a description of a child without ADHD. Similarly, teachers presented with vignettes of children with ADHD experienced more negative expectations, rating them as more disruptive to the classroom (Ohan et al., 2011). Conversely, when teachers possess greater knowledge levels of ADHD, it helps to guide their evaluations and behaviours, leading to more favourable attitudes (Amha & Azale, 2022). Such knowledge also increases the likelihood that teachers recognise and acknowledge the potential stigma faced by those with ADHD and provide the necessary support required to help negate the impact of stigma on those with ADHD (Blotnicky-Gallant et al., 2015).

Despite the evidence outlined above, literature on the relationship between knowledge and attitudes towards ADHD reveals inconsistent results, with some studies reporting positive correlations (Nur & Kavakci, 2010; Alfageer et al., 2018) and others no relationship at all (Youssef et al., 2015; Anderson et al., 2017). Ghanizadeh et al. (2006) claim that the more knowledge teachers have about children with ADHD, the more positive their attitude towards the inclusion of children with this disorder. Greenway and Rees Edwards (2020) reported a significant positive correlation between knowledge and attitudes, indicating the higher the knowledge score, the more positive the attitude. However, the results of this study and previous studies (see Anderson et al., 2012, 2017) provide a complex picture. For example, teachers in Greenway and Rees Edwards' study revealed only adequate knowledge levels and ambivalent attitudes, meaning teachers hold positive and negative beliefs and feelings about ADHD. In particular, 70% of teachers agreed with positive belief and feeling statements, *students with ADHD are rewarding to work with*, and *ADHD is a valid diagnosis*. However, 69% of teachers held negative feelings towards ADHD. For example, only 7% of teachers disagreed with the statement that *ADHD interferes with their teaching*, 79% agreed that *behaviours associated with ADHD are irritating in the classroom*, and 61% agreed that *ADHD-type behaviours cause me to experience stress*. Under half (46%) of teachers disagreed with negative belief statements. For example, 29% of teachers disagreed that *ADHD is over-diagnosed*, and 69% disagreed that *children who exhibit ADHD-type behaviours are deliberately misbehaving*. Much of the research on ambivalent attitudes suggests that they reflect a weak attitude and are related to negative behavioural intentions. However, since ambivalence reduces confidence in one's evaluation, there is a tendency to increase information processing and cognitive elaboration (Jonas et al., 2000). Therefore, regarding ambivalence towards ADHD, the motivation required to carry out these cognitive evaluations may lead teachers to examine their attitudes more closely to reduce ambivalence. And since ambivalent attitudes are more susceptible to persuasion (Armitage & Conner, 2004), then with appropriate knowledge of ADHD, teachers may change certain beliefs and behaviours for the better.

Conversely, in 2016, Liang and Gao found no relationship between knowledge and attitudes in a study of pre-service and in-service teachers in Hong Kong. Although knowledge levels were average (69% for in-service and 67% for pre-service teachers), attitudes were, on the whole, negative. For example, most teachers believed ADHD is caused by bad parenting and cited increased workload, large class sizes and insufficient training as reasons for their negative attitudes. The teachers also stated that such factors had impacted their confidence in dealing with the behaviours associated with ADHD. Similarly, Anderson et al. (2017) reported no significant association between knowledge and attitudes, despite the attitudinal ambivalence among the teachers in their study. For example, knowledgeable teachers exhibited more consistent behaviours towards children with ADHD (i.e., adapting lessons and giving the child attention and support). Still, they held less consistent beliefs about ADHD (i.e., not agreeing that children with ADHD were rewarding to teach). The authors concluded that ambivalent attitudes are unsurprising since the disruptive behaviours associated with ADHD and the often conflicting information presented by the media can challenge a teacher's decisions and interactions with children with ADHD. They also call for more support and knowledge training for teachers who work with children with ADHD.

The mixed findings above show the intricate nature of knowledge and its effect on attitudes. Therefore, care needs to be taken when interpreting studies that report a relationship between knowledge and attitudes towards ADHD. Furthermore, methodological, teaching practices and cultural differences make comparisons and conclusions across studies difficult. For example, Greenway and Rees Edwards examined 165 Welsh primary and secondary teachers and Anderson et al. 127 Australian primary and secondary school teachers. In contrast, Liang and Gao investigated only 35 Chinese secondary school teachers. The diagnosis rates, educational systems and societal beliefs surrounding ADHD differ greatly across these countries, which will undoubtedly impact teacher knowledge and subsequent attitudes towards ADHD.

Furthermore, teachers in the Welsh and Australian studies had an average of 17 and 15 years (respectively) of teaching experience. In contrast, Liang and Gao do not state their teachers' years of teaching experience. Additionally, 105 Welsh and 45 Australian teachers reported receiving ADHD training compared to just nine in Liang and Gao's study. This may have contributed to the difference in attitudes and the significant relationship between knowledge and attitudes. Despite the inconsistencies across studies, the relationship between teacher knowledge and attitudes towards ADHD remains important and needs further examination. A better understanding of the relationship between knowledge and attitudes may help teachers to adjust their behaviours and attitudes towards those with ADHD. Furthermore, understanding what ADHD means for a child's education and the impact of poor knowledge on attitudes should help improve classroom environments for all children.

8.6 How Is Teacher Knowledge of ADHD Measured?

Many scales have been developed over the last few decades to address teacher knowledge of ADHD. In the 90s, Jerome et al. (1994) created the ADHD Knowledge Scale followed by Barbaresi and Olsen's (1998) ADHD Knowledge Questionnaire. The ADHD Knowledge Scale (Jerome et al., 1994) has been used and modified many times, and subsequent scales have been developed using its characteristics (Bekle, 2004; Curtis et al., 2006; Ohan et al., 2008; Barbaresi & Olsen, 1998). Questions assess demographic information (20 demographic items – age, gender, ADHD training, etc.) and specific information on diagnosis and treatment of the disorder (13 positive and 7 negative items) with a dichotomous (True or False) response format. Questions include *ADHD is a medical disorder that can only be treated with medication*, and *most ADHD children outgrow their disorder and are normal as adults*, and *a child can be appropriately labelled as ADHD and not necessarily present as over-active*. The scale's strengths are its simplicity and the fact that it was one of the first to measure elementary school teachers' knowledge of ADHD. However, it has received much criticism since some crucial steps in its development and validation were neglected. For example, the scale was not reviewed by expert panel members, placing its reliability into question. Additionally, using a dichotomous response format may encourage respondents to guess the answers or lead to an inflation of correct responses by simply agreeing with the response, thus causing false or biased results (Krosnick, 1999). Also, the validity of the scale is questionable as the psychometric evidence is limited.

It was in the year 2000 that Sciutto et al. created the most widely used scale today – the Knowledge of Attention Deficit Disorders Scale (KADDS). In this decade, a further six knowledge scales were developed: Attention-Deficit Hyperactivity Disorder Knowledge and Opinion Survey (AKOSIV) – Knowledge Scale (Power & Rostain, 2003); Attention Deficit Hyperactivity Disorder and Stimulant Medication Survey (Snider et al., 2003); Attention Deficit Hyperactivity Disorder (ADHD) Questionnaire (Kos et al., 2006); Knowledge of ADHD Rating Evaluation (KARE) (Vereb & DiPerna, 2004); The knowledge about Attention Deficit Disorder Questionnaire (KADD-Q) (West et al., 2005) and the Teacher knowledge about ADHD (Jones & Chronis-Tuscano, 2008).

The Knowledge of Attention Deficit Disorders Scale (KADDS) is a 36-item questionnaire (18 positive items and 18 negative items) which covers teachers' knowledge in three areas: (1) general knowledge of the disorder (15 items), (2) symptoms and diagnosis (9 items), and (3) treatment of the disorder (12 items). Questions include *ADHD children often fidget or squirm in their seats*, and *reducing dietary intake of sugar or food additives is generally effective in reducing the symptoms of ADHD*, and *in school-age children, the prevalence of ADHD in males and females is equivalent*. Unlike the ADHD Knowledge Scale, it has a third option response – Don't Know, which improves on the issues associated with dichotomous formats and allows differentiation between guessing or incorrect responses and a lack of knowledge. Unlike the scales developed prior to the KADDS, the authors published the reliability and validity indices and documented the empirical literature used in the scale's item construction. They also ran preliminary investigations to explore reliability coefficients, and the scale's items were modified following these investigations. Initially, the scale obtained a coefficient alpha of 0.81 and internal consistency with Cronbach's alphas ranging from 0.71 on the subscales to 0.86 for the overall scale. The scale has also been praised for its simplistic, easy-to-answer questions due to the brief and concise instructions. However, the scale also has several limitations. For example, the study had a small sample of 143 respondents, and the panel experts were homogeneous from the same doctoral programme. Finally, the psychometric scale was not assessed against other scales, nor did it undergo factor analysis.

In 2006, Kos et al. took elements from the ADHD Knowledge Scale and KADDS to create the Attention Deficit Hyperactivity Disorder (ADHD) Questionnaire. The questionnaire assesses the perceived and actual knowledge of primary teachers and trainee teachers of ADHD. The scale has 131 items divided into six sections: socio-demographic, actual knowledge of ADHD, teaching strategies, beliefs about ADHD, an evaluation of those beliefs, and ADHD-specific training needs. The scale also incorporates several different response formats. For example, an analogue scale of 10 cm ranging from very little to a lot, a second ranging from strongly agree to strongly disagree, three option response format

(True, False, Don't know) and vignettes with multiple choice and open questions. Questions include *ADHD can be inherited*, and *there is approximately one child in every classroom with a diagnosis of ADHD*. Despite the content of this scale covering a wide variety of information on ADHD, it has been criticised for its length and complexity. For example, 131 questions and the range of response formats make interpreting the responses and scores difficult, compromising the response rate, sample representativeness and data quality. In addition, alongside the small homogenous sample (165 respondents), the authors did not publish the scale's psychometric properties.

More recently, Mulholland et al. (2015) created the ADHD-specific knowledge scale (SASK). Section A addresses demographic information, and section B has 20 questions that assess teacher knowledge about the characteristics, aetiology and management of ADHD via a three-option response format (True/False/Don't Know). Questions include *children who present with ADHD behaviours, regardless of ADHD diagnosis, can benefit from individualised behaviour management strategies*, and *teachers are often the first to recognise ADHD-type behaviours and refer children for assessment*. As with the KADDS, the authors published the reliability and validity indices and documented the empirical literature used in the scale's item construction. The SASK has good internal consistency, evident in the alpha value of 0.88 derived from the split sample and split-half analysis. The construct validity of the SASA scale was also supported by both exploratory and confirmatory factor analysis with principal axis. For each factor, Cronbach's alpha values ranged between 0.77 and 0.89, demonstrating good internal consistency. The sample size of 546 is also larger than many of the previous scale validation studies. However, this scale has only been used by one other study (Greenway & Rees Edwards, 2020), so interpretations of findings from the SASK need caution until further studies have used it.

In sum, although the scales above are helpful for understanding teacher knowledge of ADHD, care needs to be taken when interpreting the scales' results since the majority do not have robust psychometric properties, and many lack clear justification and details surrounding their methodologies. For example, the scales differ in the number of items, their content, response formats, sample sizes and the collection of socio-demographic information (Soroa et al., 2013). These issues appear to go some way towards explaining the different knowledge levels of ADHD between studies over the years. However, due to the poor methodological information provided by many authors, it is unclear if recent improvements in knowledge of ADHD are due to the development and administration of the scales or increased awareness, experience and specific training opportunities accessed by teachers.

8.7 The Extent of Teacher Knowledge

Based on the information presented in this chapter, it is not surprising that the research on teacher knowledge of ADHD is inconsistent. The range of instruments used to measure knowledge, the varying educational practices, different countries and cultural expectations make it hard to compare the findings to provide an accurate representation of teacher knowledge. The next section of the chapter presents studies across three continents, highlighting some of the difficulties of comparing and assessing teacher knowledge of ADHD. The three continents are the Middle East, the United Kingdom and Australia. These regions were chosen due to their diverse educational and cultural practices, different prevalence rates and recent investigations into teacher knowledge of ADHD.

8.7.1 Teacher Knowledge in the Middle East

Saudi Arabia has seen much research on teacher knowledge of ADHD in recent years (Alkahtani, 2013; Abed et al., 2014; Alfageer et al., 2018). Prevalence rates for school-aged children with ADHD in Saudi Arabia range from 2.7% to 7.4% (Alqahtani, 2010; Alhraiwil et al., 2015; Homidi et al., 2013; Al Daajani et al., 2021). Since 1995 the country has moved towards providing those with a disability special education services in mainstream schools. Students are either taught in self-contained classes in regular public schools (partial mainstream) or through special education support programmes, which include resource rooms, itinerant teacher programs and teacher-consultant programs (full mainstream) (Al-Mousa, 2010). Special education provision in Saudi Arabia has advanced from the three categories of disability (blind, deaf and intellectually disabled) developed in the 70s to different categories of disability by targeting two groups of students. The first group includes gifted, learning disabled, physically disabled, behavioural and emotionally disturbed, communication problems, hard of hearing and low vision. These categories are already in regular schools, and the full mainstreaming programmes provide their education. The second group's education provision comes from separate special schools or self-contained classes and includes categories of blind, deaf, intellectual disabilities and autism (Battal, 2016). ADHD falls into the first group, so children with the disorder are educated through the full mainstream route. In Saudi Arabia, as in other countries, teachers receive very little ADHD-specific training. They often complete modules on educating children with special educational needs, but this is only one aspect of their undergraduate degree training, and the focus is not on ADHD (Abed & Shackelford, 2020).

The lack of training for pre-service teachers may explain the low knowledge levels reported in the following two studies. Teachers in Alkahtani's (2013) study scored poorly on knowledge of ADHD by answering only 17.2% of questions correctly. Likewise, for the subscale assessing symptoms/diagnosis of ADHD, teachers responded correctly to 18% of questions; for the final subscale on the treatment of ADHD, just under 17% responded correctly. The low percentage of correctly answered questions and the selection of don't know responses on almost 60% of the questions is concerning and shows a serious lack of knowledge.

Similar poor knowledge levels were reported by Al-Omari et al. (2015). Using a self-report questionnaire developed by Ghanizadeh et al. (2006), the authors measured knowledge levels in 130 teachers across 13 primary schools in Jordan. The mean score for teacher knowledge was 6.9 (range: 4–11) out of a maximum score of 12. Only five items were answered correctly by more than 70% of teachers in the sample, with another five items answered correctly by less than 50% of the teachers. Knowledge of the causes and treatment of ADHD was mixed. For example, over three-quarters of teachers (76.2%) reported that *ADHD is a serious problem which should be managed effectively*, although only 20.8% considered its related difficulties to be lifelong. Although 75% of teachers reported that ADHD is related to biological and genetic factors, the majority (76.2%) said that ADHD could be caused by poor parenting practices and parental spoiling, indicating misconceptions about the disorder.

Similarly, 48.5% thought that dysfunctional and chaotic families could be a causal factor in the development of ADHD. Over a third, (35%) of the teachers felt that sugar or food additives cause ADHD. Most teachers in the sample (93%) also thought *ADHD can be treated and managed using proper medications*. The teachers were also asked about their source of information about ADHD. More than 25% said they had received no information about the condition. Around 35% reported television and/or radio as their primary information source. Interestingly, less than 15% reported structured training programmes or educational courses as their source of information about ADHD. The lack of information described by the teachers was not surprising, given that Jordanian teachers do not receive specific training or preparation for working with children with additional needs (Al-Omari et al., 2015).

In contrast, later studies by Alfageer et al. (2018) and Amiri et al. (2017) show higher teacher knowledge. Amiri et al. reported knowledge of the symptoms (81.8% correct responses) and treatment (77.82% correct responses) of

ADHD was better than their knowledge of aetiology (69.82%) and outcomes (61.4%). Using a modified version of the KADDS, Alfageer et al. (2018) reported that just over half (59%) of the 141 Saudi Arabian male teachers in their study had good knowledge levels (mean score 61–75%) and 28% had insufficient levels (mean score ≥60%). Furthermore, the poorest knowledge was reported on questions relating to diagnosis and treatment. As in Al-Omari's study, teachers were asked about their information sources on ADHD. Forty-nine percent stated the internet as their primary source of information, followed by social media (34%). Mass media, i.e. television and books, were also used as sources of information (27% and 23%, respectively). The authors suggest that the poor knowledge levels reported may be related to their information sources (media and the internet). Like Al-Omari's findings, only 18% of teachers indicated that knowledge was obtained through structured training programs or courses. This finding has implications for the knowledge gained from potentially inaccurate and inappropriate sources often evident on the internet.

Teacher knowledge levels in the studies above show earlier research with poorer knowledge, with more recent research showing adequate levels of knowledge. Also, teachers know more about the symptoms of ADHD than anything else. What is less clear is the reason behind these changes. Are the changes due to the informal avenues of information being accessed, or are teachers being exposed to more children with ADHD in their classrooms? More research on the sources of teacher knowledge and why they lack knowledge about treatments and outcomes is required to answer this question. What is clear from the findings in this region is that those responsible for teacher training courses need to increase knowledge training on more than just symptoms. They need to incorporate appropriate interventions and empirically based information, which will override any inaccurate information from the media or unsubstantiated sources and hopefully increase overall knowledge levels.

8.7.2 Teacher Knowledge in the United Kingdom (UK)

Prevalence rates for school-aged children in the UK range between 1.9% and 5% (Murphy, 2014). Clinical practice in the United Kingdom is governed by the National Institute for Health and Care Excellence (NICE), responsible for diagnosis, treatment and ADHD-specific guidelines. In the United Kingdom, children attend school from the age of 5 to 16, and since they spend a large portion of their life at school, teachers are often the first to identify ADHD-type behaviours and, if appropriate, start the referral process. However, children diagnosed with ADHD in the United Kingdom are not recognised as having a disability and therefore not eligible for special education services. In order to access such services, the onus is very much on the parent to apply for support directly from the school's special educational service or indirectly through an educational health and care plan. Support accessed directly from the school leads to in-house interventions from trained staff (such as teaching assistants). In contrast, the care plan is a legal mechanism that provides children with 'a statement' to access significantly more external support from educational psychologists and parent training programmes (Singh, 2017).

ADHD is perceived as a social rather than a medical issue in the United Kingdom due to poor classroom behaviour management, peer bullying and parental attitudes. The parent attitudes of 'just getting on with it' coupled with the British stiff upper lip go some way to explaining the lower diagnosis and use of drug treatment in the United Kingdom (Singh, 2017). Similarly, the stigma associated with the label of ADHD and the perception that children with the disorder are 'naughty' results in less help-seeking behaviour. For these reasons, teachers must possess high knowledge of ADHD to work with parents to help them understand the disorder so that both teachers and parents can provide the best care and support for those with ADHD.

Research that examines teacher knowledge in the United Kingdom is sparse. Of the existing studies, results on the level of knowledge among teachers are poor to adequate. In one study, Akram et al. (2009) examined qualified ($N = 43$) and student ($N = 25$) teachers' general knowledge of ADHD and knowledge of pharmacological treatments. Questions on prevalence, gender differences and inheritability were followed by more specific questions such as *when stimulants are used, they improve a child's academic performance*, and *almost 30% of children with ADHD do not respond to stimulant medication*. The authors reported low general knowledge of ADHD, with both qualified and student teachers answering on average 5 out of 15 questions correctly. Knowledge of medication was also poor, as evidenced by the relatively low proportions of correct responses to each question. Most respondents knew that medication was not a cure for ADHD, but just under half incorrectly believed that a positive response to stimulants is indicative of underlying ADHD. The authors raise their concerns about the fact that qualified teachers had similar knowledge to that of the student teachers, especially when the qualified teachers are at the heart of support and teaching provision for children with ADHD.

More recently, in their study that compared 165 teachers and 157 TA knowledge and attitudes towards ADHD, Greenway and Rees Edwards (2020) reported adequate (<50–85% correct) levels of knowledge with teachers answering an average of 62% of questions correctly. The most accurate knowledge focused on symptoms (74%), followed by treatments (60%) and the poorest knowledge was recorded for aetiology (48%) and prevalence/assessment (48%). These figures confirm previous international findings (Anderson et al., 2012; Amiri et al., 2017; Mulholland et al., 2015; Shroff et al., 2017) and indicate a need for future training programmes to incorporate and strengthen information on the causes and extent of ADHD in the classroom. The accurate knowledge of symptoms in Greenway and Rees Edwards' study is not surprising since teachers deal with ADHD-type behaviours regularly and often rely on their knowledge of symptoms to inform classroom practice and intervention choices and make referrals for assessment. However, knowledge of symptoms and treatments was only adequate (<50–85% correct). The adequate knowledge may be attributable to the lack of ADHD-specific training available on initial teacher-training courses in the United Kingdom and subsequent training opportunities for in-service teachers. In 2018, the National Institute for Health and Care Excellence (NICE, 2018) guidelines for ADHD called for the Department of Education to provide more education for teachers and trainee teachers amidst concerns that around half of all cases of ADHD in school-aged children go undiagnosed.

The most recent study in the United Kingdom that examines teacher knowledge of ADHD was carried out by McDougal et al. (2022). Using semi-structured interviews, the authors asked six primary school teachers *what is your understanding of ADHD or can you describe a typical child with ADHD*. As in previous studies, teacher knowledge focused on the core symptoms of ADHD. For example, all teachers spoke about attention or concentration difficulties, and most teachers referred to hyperactive symptoms such as moving around or being 'in overdrive'. Similarly, teachers described the social challenges associated with ADHD, such as an inability to follow social rules, inappropriate reactions to certain social situations and poor emotional regulation. The teachers also spoke about how these challenges act as barriers to collaborative learning. Finally, some teachers mentioned academic difficulties with subjects such as maths and literacy and how these were often exacerbated by low confidence in carrying out specific tasks. The authors concluded that, on the whole, teachers had good knowledge of symptoms, although they acknowledged social and cognitive difficulties, these were discussed to a lesser extent. These results are similar to the findings in the quantitative literature and have important implications for future classroom interventions and training programs. In particular, information on social and cognitive difficulties such as executive functioning and memory issues needs to be included. However, despite the novel use of interviews to measure knowledge, six participants are not representative of all teachers who work with children with ADHD. Furthermore, the sample may have been biased because the teachers who agreed to be interviewed may have done so because of their knowledge and commitment to understanding ADHD.

It appears that from the studies above, adequate or up-to-date knowledge of ADHD is not available in UK teacher-training programmes. The findings indicate a need for educators to incorporate core ADHD content that provides knowledge about more than symptoms and diagnostic criteria. Furthermore, since all respondents across the three studies highlight the need for further knowledge training on ADHD, there is a clear steer for appropriate in-service training programmes that explore treatments, aetiology and outcomes of the disorder. Without such training, teachers will continue to feel underprepared and out of their depth when faced with children with ADHD in the classroom.

8.7.3 Teacher Knowledge in Australia

ADHD prevalence rates for school-aged children in Australia are considerably higher than in the United Kingdom and stand between 6% and 9% (Al-Yagon et al., 2013). The health authority responsible for advice on assessing and managing medical conditions is the Australian National Health and Medical Research Council (NHMRC). Within this authority, paediatricians and psychiatrists are responsible for diagnosing and treating children with ADHD (Starling et al., 2013). However, unlike in the United Kingdom, educational professionals and teachers, although encouraged to refer children, are not involved in providing information to support diagnostic assessment (Prosser & Reid, 2013).

In Australia (as in the United Kingdom), a diagnosis of ADHD is not sufficient to access funding for support within the classroom. Without this funding, children cannot access the reasonable adjustments that support all students with disability outlined by the Disability Standards for Education. This has led to health professionals providing a diagnosis of autistic spectrum disorder (ASD) alongside ADHD to access individual targeted funding (Graham, 2015). Such decisions affect schools and teachers when providing appropriate support and educational interventions if students are not receiving the correct diagnosis. A further issue relates to the fact that Australian children are significantly more likely to be medicated than those in the United Kingdom due to prescription drugs being the first line of defence in treating children with ADHD. Prescriptions for ADHD have grown significantly over the past few decades, and between 2017 and 2020, the figures have increased by over 52%, reaching 167,950 children aged 0–18 in 2020 (Klau et al., 2021). Despite these figures, Australia has no current guidelines for ADHD. The lack of funding for students with ADHD, the misdiagnosis, high prescription rates and lack of guidelines raise significant challenges for Australian teachers who may have the knowledge of symptoms and be able to recognise children's special educational needs but do not have the skills or support to adjust curriculum or practice accommodations for children with ADHD (Graham, 2015).

In an early study of Australian teachers' knowledge of ADHD, West et al. (2005) expanded the KADDS (Sciutto et al., 2000) from the original 20 items to 67 items. Two hundred and fifty-six primary and secondary teachers were asked about their knowledge of the characteristics, causes and treatments. Unlike the original KADDS, West et al. provided evidence of internal consistency for the scale as a whole and the three subscales. The teacher's overall average score was 36.08 for correct responses indicating low knowledge levels. The best knowledge was on the causes subscale with a mean of 65.2, followed by the characteristics subscale 59.0 and 47.8 on the treatment subscale. The most common items answered correctly were those relating to the characteristics of ADHD. For example, 90% of teachers correctly answered that children with ADHD tend to have poor concentration and can be inattentive and that attention levels improve following stimulant medication use. Of importance, 89% of teachers knew that a combination of medication and behaviour management is currently a highly recommended treatment for ADHD. Some of the most common items answered incorrectly included 48% of teachers incorrectly responding to children with ADHD do not talk excessively in class, and 39% answered incorrectly to the question on children with ADHD tending to be verbally aggressive. While 34% of teachers incorrectly identified special diets as an effective form of treatment for ADHD. The most common items chosen for don't know responses were from the treatment subscale. For example, 86% of teachers did not know whether biofeedback was an effective treatment for ADHD. Worryingly, 63% responded I don't know to *Electroconvulsive Therapy (ECT) is an effective treatment for ADHD*. This study shows, like many others (Sciutto et al., 2000), that teachers know more about the characteristics of ADHD and less about the treatments. This finding has serious implications for students with ADHD since teachers are often responsible for implementing, managing and evaluating classroom interventions.

In their study of in-service and pre-service teachers, Anderson et al. (2012) investigated teachers' perceived knowledge of ADHD alongside their actual knowledge. The authors reported that both groups had realistic perceptions of their knowledge, evident in the relationship between perceived knowledge and actual knowledge. Pre-service teachers scored around 52% on total knowledge compared to 60% for in-service teachers. In-service teachers had higher knowledge of characteristics and treatments for ADHD than did pre-service teachers. Scores for both groups were similar for knowledge of causes which the authors suggest may reflect an emphasis on the aetiology of ADHD in university training courses in Australia. However, pre-service teachers' highest scoring subscale was on the causes of ADHD and in-service on the characteristics subscale. The authors suggest that since the characteristics represent those evident in classrooms, in-service teachers would be more likely to have been exposed to those behaviours, indicating that knowledge of ADHD develops after teachers gain classroom experience rather than during their university education. As with West et al. (2005) and the studies from the United Kingdom, knowledge of treatments may have been low due to inadequate or out-of-date information from university courses and in-service training. A failure to provide appropriate training about treatments for ADHD will hamper teachers' ability to understand and effectively implement interventions, again stressing the need for improvements in teacher training and continuing professional development (CPD) services that specifically focus on treatments.

In Mulholland et al.'s (2015) study, teachers' knowledge was higher than that reported in West's and Anderson's study. Teachers answered 62% of questions correctly, equating to adequate knowledge levels (<50–85% correct). The best knowledge was on the symptom subscale (71.3%), and the poorest knowledge was on questions related to prevalence and assessment (39.5%). The authors indicate that adequate knowledge levels may be attributable to the teacher's engagement in professional learning and wider reading or more exposure to students who exhibit ADHD-type behaviours. However, since the authors did not ask about the nature of teachers' professional learning or the amount of exposure to ADHD-type behaviours, caution on any interpretation is needed.

Early Australian studies, like those in the Middle East, show lower knowledge levels which appear to increase in the later, more recent studies. Reasons for this may include improvements and the creation of new scales to measure teacher knowledge (as seen in Mulholland et al.'s SASK) or changes to physical classroom environments and the curriculum in recent years. Furthermore, the prevalence rates of ADHD in Australia are high, which increases the number of children with ADHD in the classroom. As Anderson et al. (2012) and Mulholland et al. (2015) suggest, knowledge is more likely to develop through experience working with children with ADHD. However, this may help identify symptoms and prevalence rates but will not necessarily inform teachers about appropriate treatment interventions and prognosis.

It is evident from the literature on teacher knowledge of ADHD that more needs to be done to investigate how teachers work with children with ADHD despite their poor to adequate levels of knowledge. Recent research has moved away from quantitative knowledge measures to discover teachers' everyday experiences working with children with ADHD. To this end, Moore et al. (2017) conducted focus groups with 39 UK-based educators. They were specifically interested in their experiences responding to ADHD in the classroom and exploring the facilitators and barriers to supporting children with ADHD. Unfortunately, teachers tended to reflect on general inclusive strategies rather than those focusing on ADHD. In the same year, Lawrence et al. (2017) asked teachers about their strategies for children with ADHD. The authors reported the techniques were predominantly behaviour based (allowing children to fidget or move around the classroom). These studies show a distinct lack of appropriate strategies when working with children with ADHD. Thus teachers need training that focuses explicitly on classroom interventions that address not only behavioural symptoms but the cognitive difficulties often experienced, which often lead to poor educational outcomes in children with ADHD.

8.8 Factors that Affect Teacher Knowledge

Over the past decade, research has focused on several factors affecting teacher knowledge of ADHD, some of which have been touched upon already. These include the experience of teaching children with ADHD, years of service, teacher efficacy and ADHD-specific training. The literature on the effect of years of service and experience with ADHD on knowledge is inconsistent. For example, Mulholland et al. (2015) and Aljohani (2018) observed that as teaching experience increased, so did knowledge of ADHD, whereas Stampoltzis and Antonopoulou (2013), Shroff et al. (2017) and Greenway and Rees Edwards (2020) report no relationship between years of service and knowledge.

In their study of teacher characteristics as predictors for teacher knowledge and attitudes towards ADHD, Mulholland et al. (2015) asked 116 primary and secondary school teachers to complete a knowledge questionnaire that the authors adapted from existing surveys (i.e., Akram et al., 2009; Bekle, 2004; Bishop & Boag, 2006; Norvilitis & Fang, 2005; Ohan et al., 2008; Rush & Harrison, 2008). The questions related to teacher knowledge of ADHD-type behaviours, possible causes and the effects of these behaviours in the classroom. The results showed that years of teaching were a significant predictor of teacher knowledge, revealing that as years of experience increased, so did teacher knowledge. The authors suggest this could result from engagement with professional development and more time spent teaching children with ADHD. This finding confirms the results reported by Anderson et al. (2012), who found that in-service teachers had greater knowledge of ADHD than pre-service teachers, supporting the notion that crucial information for understanding ADHD is gained within the classroom rather than through teacher training courses. In contrast, Weyandt et al. (2009) reported that teachers with fewer years of service demonstrated significantly greater knowledge than those with more years of service, suggesting that teaching experience does not necessarily equate to having greater knowledge. This finding could be because of curriculum changes in teacher education since 2009 that focus on special education provision or increased media coverage surrounding ADHD in recent years.

In their study of 106 teachers from 12 English medium schools in Mumbai, Shroff et al. (2017) reported that teachers lacked adequate knowledge by responding correctly to only 49% of questions. As with previous studies, knowledge was best on ADHD symptoms and poorest on treatments. However, unlike in Mullholland's and Weyandt's studies, no relationship was found between years of teaching and knowledge. The authors suggest that this may result from a lack of awareness of the disorder since training is in its early stages in India. Therefore, teachers would not necessarily have learnt about the disorder or taught a child with ADHD. In addition, India's teacher training programmes have undergone many revisions in recent years to focus on inclusive education and developmental disorders. These changes could explain the lack of relationship between years of experience in teacher knowledge since those in-service teachers with more years of teaching experience would not have benefitted from the changes to teacher training programmes. The findings by Shroff et al. highlight the importance of considering cultural and educational differences when comparing teacher knowledge of ADHD.

Few studies have examined the effect of teaching a child with ADHD on knowledge since studies either do not ask the question or show that most teachers have taught a child with ADHD, making comparisons difficult. In one study, Youssef et al. (2015) examined the knowledge of 277 primary and secondary school teachers in Trinidad. Teachers had low knowledge levels, correctly responding to 45% of questions. Most teachers chose the don't know option instead of incorrect answers, which shows uncertainty rather than misconceptions about ADHD. The authors also found that teachers who taught a child with ADHD had better knowledge than those who had not. They suggest this could result from teachers seeking ADHD-specific information and attending CPD courses to help them support those with ADHD. However, the authors did not ask teachers why they had chosen don't know more than the true or false response, so interpretations need caution.

The studies above demonstrate the importance of teachers' CPD to ensure that they are up-to-date with current literature, diagnostic criteria and interventions concerning ADHD. Most CPD training courses for ADHD have focused on improving knowledge about symptoms and aetiology, and although evidence shows they are effective (Aguiar et al., 2014; Anto & Jacob, 2014), the gains are often small and focused on limited elements of ADHD. Furthermore, since education authorities and schools do not always have the appropriate resources or funds to ensure all staff can access CPD courses, the benefits are not always far-reaching.

The gaps in knowledge discussed in this chapter can be explained partly by the limited or no ADHD-specific content in initial teacher training (ITT) programmes or poor access to CPD courses. As a result, teachers often feel that their training in teaching students with ADHD is inadequate, and many teachers indicate that further training is necessary (Lawrence et al., 2017). For example, in a survey of 803 UK teachers, 89% reported having taught students with ADHD, but 63% had received inadequate training and support for students with ADHD (ComRes, 2017). Although training programmes across different countries differ, a common thread is a narrow focus on special educational needs and requirements. For example, in the United Kingdom, the Initial Teacher Training (ITT) Core Content Framework (DfE, 2019), designed to emphasise the importance of high-quality teaching for pupils with additional needs, does not provide universities or colleges with detailed approaches specific to particular additional needs. Instead, providers are free to tailor their curriculum to the needs of their trainees, which may result in little or no ADHD-specific training. Unfortunately, this practice is mirrored across many countries, which means that for many newly qualified teachers, the first time they encounter ADHD and its challenges may be when faced with a child with ADHD in their classroom.

The evidence suggests that teachers who receive ADHD-specific training have significantly higher knowledge and fewer misconceptions about the disorder than teachers without training (Alkahtani, 2013; Jones & Chronis-Tuscano, 2008; Sciutto et al., 2016). For example, in Youssef et al. (2015), the teachers who had received training had greater knowledge than those without, but the authors do not clarify what percentage of teachers had received training compared to those who had not. In addition, teachers who undergo training feel more secure in initiating the referral process and can better implement the interventions designed to support the social, academic and emotional success of those with the disorder (Topkin & Roman, 2015). Recently, a small number of studies have evaluated training programmes and interventions to increase teacher knowledge of ADHD. However, many of them reveal only small knowledge gains. For example, in Aguiar et al.'s (2014) study, teachers showed only small increases in knowledge following a 1-day (6 h) training workshop on ADHD. However, this study's lack of a control group and follow-up analysis limits its strength.

Alkahtani (2013) and Ward (2014) reported that teacher knowledge was positively correlated with training. However, overall knowledge levels on the KADDS (Sciutto et al., 2000) between the two studies differed significantly (correct responses were 17% and 56%, respectively). One reason for the knowledge difference could be the diverse training opportunities experienced across their respective cultures. For example, Saudi Arabian teachers in Alkahtani's study did not receive ADHD training as part of their teaching training programme (Abed et al., 2014). In contrast, the Irish teachers in Ward's study would have received structured ADHD training as part of their teaching practice. The higher knowledge scores in Ward's study highlight the importance of pre-service training, but even with training, knowledge was still only adequate.

In 2019, Latouche and Gascoigne measured 274 primary school teachers' knowledge (using KADDS) and self-efficacy (using the Teachers' Sense of Self-Efficacy: Tschannen-Moran & Hoy, 2001) following a brief 2-h single-session training workshop. The first half of the workshop covered topics such as aetiology; executive functioning impairments; symptoms, diagnosis and treatment. The second half focused on classroom management strategies drawn from Barkley's (2008) Classroom Accommodations for Children with ADHD, in addition to instructions on making referrals, talking to parents and liaising with health professionals. The authors reported that the intervention increased teachers' ADHD knowledge and self-efficacy at the end of the study and 1 month later. However, a 1-month follow-up is a short period of time, so it would be beneficial to increase the length to six or nine months to measure the long-term effectiveness of the training workshop.

The following year, Alshehri et al. (2020) reported that in their study of 100 Saudi Arabian male teachers, baseline knowledge was adequate for only 16% of the intervention group and 22% of the control group (adequate knowledge ≥65% correct responses) at baseline (control group 22%). These figures rose to 70% for the intervention group following training but remained similar for the control group (20%). The authors also reported knowledge levels 3-month post-training had decreased in the intervention group (46%) but increased slightly in the control group (28%). Despite this study offering information on the effectiveness of a training programme to improve teacher knowledge of ADHD, participants were all male, which causes generalisability issues. In addition, the short 3-month follow-up is not enough time to assess the long-term effects of the training programme. Also, the authors used the same code/score for incorrect and don't know responses, making it unclear whether the teachers in this study had misconceptions or a lack of knowledge of ADHD.

Unlike previous studies, Jarque Fernández et al. (2021) investigated the effectiveness of a long-term training programme on teacher knowledge of ADHD and self-efficacy. In their study, 20 teachers consisted of a control group and 20 participated in 17 2-h psycho-education training sessions spanning the academic year. The KADDS was used to measure knowledge before and after the intervention. Self-efficacy was measured on a 7-point Likert scale by answering, 'How effectively do you think you can teach a pupil with ADHD? Answer bearing in mind that one is the lowest (not trained effectively) and seven is the highest (fully trained)'. The training sessions included general knowledge, interventions and behaviour improvement strategies, adaptation activities and teacher stress management strategies. The control and intervention groups answered around 50% of questions correctly at baseline, with the best knowledge of symptoms and the poorest knowledge of general information. The results revealed no increase in knowledge over time (post-test). Interestingly, the control group experienced a significant reduction in perceived self-efficacy over time (post-test). This reduction may have been due to completing the knowledge scale and teachers realising how poor their knowledge was.

Following training, the intervention group answered around 77% of questions correctly, with the best knowledge on the treatment subscale. In addition, knowledge scores increased significantly overall and across the three subscales (treatments, general information and symptoms/diagnosis). The intervention group also increased their level of self-efficacy following training. The authors suggest that as well as improved knowledge from the training programme, improvements in self-efficacy may be due to teachers in the intervention group reflecting on their previous teaching experiences and having the opportunity to learn vicariously from others on the course.

This study's strengths lie in the long-term approach taken across the academic year. Here teachers participated in the training alongside working with children with ADHD in the classroom. This enabled teachers to use the intervention strategies they were learning during training which meant they could receive feedback and make adjustments as required. The programme also included stress and emotional management strategies and techniques to improve communication between teachers and families of those with ADHD, which go beyond the remit of previous training programmes. However, despite this study's success in improving knowledge and self-efficacy, the small sample size, no follow-up and lack of validated self-efficacy scale limit its power. Nevertheless, the training programme's novel content and improvements to knowledge and self-efficacy pave the way for improving future training programmes. Teachers can learn a lot from others through sharing good practice. Furthermore, interacting with others with similar experiences can trigger discussions and support that may improve knowledge and self-efficacy.

Despite the gains observed in the studies above and the arguments put forward in this chapter for providing teachers with ADHD-specific training, understanding the effectiveness of training programmes is difficult because of the different outcome measures and methodologies used across studies and disciplines (i.e. psychology, medicine and education). Further issues exist due to the overreliance on non-randomised, single-arm cohorts, which increases the risk of a biased sample. In addition, across studies, the variety of designs, interventions, recruitment techniques, measurement tools and timescales pose many complications for comparison (Ward et al., 2022). With these limitations in mind, Ward et al. (2022) conducted a systematic review and meta-analysis to examine the efficacy of teacher training interventions in increasing teachers' knowledge of ADHD and positive behaviours towards children with ADHD-type behaviours. The review of 52 studies across 18 countries included both randomised and non-randomised control trials and primary and secondary school teachers. Mode of delivery varied from face-to-face sessions, web-based self-directed programmes and instructional booklets. The authors reported that in almost all studies, the ADHD training programmes were beneficial in the short term immediately after training. However, the level of knowledge was not sustained in follow-up assessments. Furthermore, due to the medium-to-high risk of bias, confounding variables, subjective outcome measures and limited detail on the randomisation process for the randomised trials, the authors offer a note of caution when interpreting the reported efficacy of training programmes in the literature.

8.9 Conclusion and Future Recommendations

This chapter paints a complex picture of teacher knowledge of ADHD. The educational and cultural differences and various tools and methodologies to measure teacher knowledge make comparisons and conclusions difficult. What is clear, however, is that there is an urgent need for teachers to increase their knowledge of ADHD beyond the adequate levels seen across most studies. In particular, they need to undergo training that explicitly addresses treatments and classroom interventions where the research shows knowledge surrounding these is poor. Further training is also required on the outcomes and prognosis for those with the disorder since research in this area is limited.

Increases in teacher knowledge should also improve behaviours and attitudes towards the disorder, student–teacher relationships and school-related outcomes for those with ADHD. Although understanding the characteristics of ADHD is essential for referral processes and classroom adjustments, it is not sufficient to enable teachers to select appropriate interventions for a child who cannot concentrate long enough to complete their math assignment. Furthermore, in a world that requires the monitoring of success and outputs, teachers need to be well-versed in a variety of interventions and techniques so that they can monitor their effectiveness and try different options if they are not working for the individual.

However, before training providers begin to roll out their courses, they may wish to consider the information outlined in this chapter. Since knowledge is associated with negative attitudes, training programmes may want to look at why a better understanding of ADHD does little to eradicate the negative attitudes towards the disorder. Greenway and Rees Edwards (2020) argue that if negative attitudes exist despite ADHD training and an improvement in knowledge, training programmes may focus too heavily on the negative behaviours and difficulties faced by children with ADHD. This argument is evident in the assumption that ADHD is inherently negative, and training programmes aim to define and reduce the negative attributes to improve student behaviours and outcomes (Barkley, 2008; Geng, 2011). However, this negative mindset needs reframing, and training programmes need to redress the balance to include positive aspects of the disorder. Training programme creators may wish to explore the adult literature on the positive attributes of ADHD. Here, hyperactivity, impulsivity, and risk-taking may afford opportunities psychologically inaccessible to neurotypical peers (Wiklund et al., 2016). These characteristics, in childhood, may present as problematic within the classroom, but in adults, they may manifest as behaviours and thought processes considered divergent thinking, adventurous, energetic and courageous (Sedgwick et al., 2019). If teachers are taught about the positive aspects of ADHD, this would positively impact attitudes and ideas about ADHD and help implement interventions that play to the strengths of individuals and improve the prognosis of those with ADHD in the future.

Finally, the recent research by Jarque Fernández et al. (2021), Moore et al. (2017), and Lawrence et al. (2017) provide some excellent ideas for future research and in designing training programmes. For example, using stress management strategies and techniques to improve communication between parents and teachers would ensure that teachers feel supported in their roles and may enhance their confidence to work effectively with children with ADHD in their classrooms and beyond. In addition, future qualitative research that explores teacher experiences in supporting children with ADHD and asking them directly where the gaps lie in their knowledge would ensure that both teacher and student needs are catered for and that they have the best experience in the classroom.

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9 Environmental Risk Factors for Attention-Deficit/Hyperactivity Disorder

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9.1 Introduction

As described in [other chapters] in this text, attention-deficit/hyperactivity disorder (ADHD) is characterized by developmentally inappropriate and cross-situational symptoms of inattention and/or hyperactivity-impulsivity (American Psychiatric Association, 2013). It is one of the most common neurodevelopmental disorders, with an estimated prevalence of approximately 8% (8–17 years; Danielson et al., 2018), with increasing prevalence documented in the past several decades (Polanczyk et al., 2014). This has resulted in the need to systematically examine risk factors that may contribute to the development of ADHD. Although ADHD is highly heritable—indeed, one of the most heritable psychiatric conditions, with estimates around 0.70–0.80 (Faraone & Larsson, 2019)—research also highlights the potential etiological role of various environmental risk factors (Carlsson et al., 2021). The etiology of ADHD is multifactorial, emphasizing the importance of understanding the influence of both environmental and genetic factors as well as their interactions. Additionally, exposure to environmental factors might result in epigenetic changes (e.g., DNA methylation) that modulate the expression of genes associated with ADHD (Walton et al., 2017), although research in this area is limited and largely speculative, requiring more systematic investigation. This is especially important as genetic factors may not be modifiable. That is, in order to reduce the risk of impairments associated with ADHD, identifying and understanding the influence of environmental risk factors that may play a role in the emergence of the ADHD phenotype is key. Examples of such factors include prenatal substance use, exposure to environmental toxins, gestational age/prematurity, diet, and lifestyle/psychosocial adversity. In this chapter, we summarize the findings of studies examining associations between ADHD or ADHD-related traits and environmental risk factors.

The current chapter focuses on five sections: (1) prenatal factors; (2) perinatal and childbirth-related factors; (3) postnatal factors; (4) gene–environment interaction; and (5) protective factors associated with ADHD. Table 9.1 summarizes the contents of this chapter. Throughout, we rely on original research, systematic reviews, and meta-analyses, highlight potential moderators and mediators of associations when known, and specify potential reasons behind discrepancies between studies.

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Table 9.1 Environmental risk factors for ADHD

Prenatal risk factors	Perinatal and childbirth-related risk factors	Postnatal risk factors
Maternal mental health Maternal distress Maternal physical health Maternal nutrition Gestational anemia Pre-pregnancy maternal BMI and obesity Hypertensive disorders and preeclampsia Maternal diabetes Maternal medication and substance use Antidepressants and other neuropsychiatric medications Caffeine, alcohol, and smoking Opioids, cocaine, and methamphetamine Polysubstance use Maternal exposure to environmental toxins Lead Mercury Polychlorinated Biphenyls (PCBs) Air pollution and other commonly encountered toxins	Parental age at childbirth Prematurity and low birth weight Method of delivery and labor induction	Exposure to environmental toxins Lead Manganese Polychlorinated Biphenyls (PCBs) Organophosphate pesticides (OP) Air pollution Psychosocial factors Socioeconomic status (SES) Extreme early deprivation Parenting styles Electronic media exposure Nutrition

9.2 Prenatal Risk Factors for ADHD

The fetal programming hypothesis theorizes that offspring respond adaptively to their prenatal environment, which can confer risk for a range of mental and physical health outcomes (Gluckman & Hanson, 2004). This hypothesis has been used to partially explain the emergence of several clinical phenotypes, including ADHD, which are thought to arise when there is a mismatch between one's prenatal and postnatal environments (Kim et al., 2015; Mill & Petronis, 2008). In other words, the course of an offspring's development can be changed during the prenatal period. This change can be favorable in the short term, allowing one to fare better in the first environment to which they are exposed. However, this change can also be unfavorable in the long term when, during the postnatal period, one is exposed to other environments that have new demands and require different responses. For example, early exposure to nicotine in the uterus may modify cholinergic, catecholaminergic, and serotonergic systems in ways that are initially adaptive (e.g., activation of nicotinic acetylcholine receptors and subsequent onset of neurodevelopmental events typically driven by acetylcholine) but eventually become maladaptive (e.g., difficulties with working memory; Blood-Siegfried & Rende, 2010; Kian et al., 2022).

Prenatal risk factors have been a focus of the literature on ADHD for decades. Findings have been somewhat inconsistent, likely due to methodological variation across studies, but notable factors that have been associated with increased risk for ADHD include *pre-pregnancy* maternal body mass index (BMI) in the "overweight" or "obese" range, diabetes, maternal stress, depression, hypertensive disorders (e.g., preeclampsia), as well as exposure to antidepressants (SSRI and non-SSRI), acetaminophen, cigarette smoke, and alcohol *during pregnancy* (Carlsson et al., 2021; Kian et al., 2022; Kim et al., 2020). This section elaborates on risk factors with the most robust evidence but is not exhaustive or inclusive of all factors that have been investigated.

9.2.1 Maternal Mental Health

9.2.1.1 Maternal Distress

Many studies have found a positive association between prenatal maternal distress and ADHD in offspring (Bendiksen et al., 2020; Shih et al., 2022). Maternal distress has been generally conceptualized in terms of stress, anxiety, and depression. Stressors can vary in duration, intensity, and reach; they can be acute or chronic, mild or severe, and affect a specific individual or a broader community. A systematic review by Van den Bergh et al. (2020) described four studies (Class et al., 2014; Li et al., 2010; Ronald et al., 2011; Zhu et al., 2015) that found significant positive associations between prenatal maternal stress and ADHD diagnosis or symptoms in offspring. These associations spanned trimesters and remained significant even when potential confounders, such as child sex and gestational age, maternal smoking status during pregnancy, maternal and paternal age at conception, and psychiatric histories, were considered. Three of these studies' findings were sex-specific: Li et al. (2010; $N = 1{,}015{,}912$, age $\geq$ 3 years) and Ronald et al. (2011; $N = 1710$, age = 1–3 years) found significant positive associations between stress experienced during the prenatal period (e.g., financial difficulties, marital problems, bereavement) and ADHD diagnosis (Li et al., 2010), ADHD medication use (Li et al., 2010), and ADHD symptoms (Ronald et al., 2011) in male offspring. Zhu et al. (2015) found stronger associations between stress measured in the *second* trimester and dimensional ADHD symptoms in male offspring, whereas in females, stress during the *third* trimester played a stronger role. When categorical symptoms (dichotomized based on whether scores were above or below clinical cutoffs) were used, a significant effect remained for only male offspring. Additionally, Zhu et al. (2015; $N = 1765$, age = 4–4.5 years) found lower social support and higher avoidance coping during the prenatal period in mothers of male offspring with clinically elevated ADHD symptoms as compared to mothers of females.

In another systematic review and meta-analysis of 12 studies published in 1990–2016, non-adjusted results showed a significant positive association between prenatal maternal stress and ADHD in offspring, with children of mothers who experienced psychological and/or environmental stress during pregnancy being more than twice as likely to display ADHD symptoms than unexposed comparison children. After adjusting for potential confounders (e.g., whether the child was delivered preterm, family socio-economic status), the association remained significant but weakened (i.e., the pooled odds ratio [OR] decreased from 2.69 to 1.72) (Manzari et al., 2019). After adding four studies to the analysis to correct for suspected publication bias, the pooled OR reduced even further, from 1.72 to 1.22, and the association was no longer significant. Point estimates also varied when studies were grouped based on their characteristics, such as design, stressor timing and type, ADHD measure, and quality, and data were analyzed within subgroups, although the number of studies within each subgroup was often low. Taken together, while there is evidence of an association between prenatal maternal stress and ADHD in offspring, findings can differ based on methodological choices.

Although maternal stress, depression, and anxiety have been commonly conceptualized as environmental risk factors, they also carry genetic effects. For example, the genetic effects of prenatal maternal depression have been estimated to account for 17% of the variability in ADHD symptoms in offspring (Eilertsen et al., 2021). After controlling for genetic effects using children-of-twin models, which sample children of monozygotic and dizygotic twin parents to parse environmental effects from genetic effects, one study found that a significant positive association between prenatal maternal depression and ADHD in offspring remained (Eilertsen et al., 2021). Possible mediators of such associations include the activation of glucocorticoids and cytokines, which are inflammatory markers (Gustafsson et al., 2020) and can cross directly into the uterus through the placenta, altering the structure and function of the developing brain

(O'Donnell et al., 2012; Shao et al., 2020). Early perturbations in the offspring's neurodevelopment due to exposure to prenatal maternal anxiety and depression may also manifest in later differences in cognitive processes, including cognitive control and reward processing (Adamson et al., 2018; Hicks et al., 2019; Van den Bergh et al., 2020; Wei et al., 2022), which might be linked to ADHD. However, these associations could also be moderated by other variables. Examples of possible moderators include the catechol-O-methyltransferase (COMT) genotype (prenatal maternal anxiety-offspring ADHD; O'Donnell et al., 2017) and vitamin D levels (prenatal maternal depression-offspring ADHD; García-Serna & Morales, 2020; Ma et al., 2021).

There are, however, some inconsistencies in findings related to prenatal maternal distress and ADHD in offspring, even in large, population-based samples. For example, in the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort ($N = 2280$), there was a significant positive association between prenatal maternal anxiety, prenatal maternal depression, and ADHD in offspring, but this was not replicated in the Generation R cohort ($N = 3442$; Van Batenburg-Eddes et al., 2013). Notably, between the two cohorts, ADHD symptoms were assessed at different ages (age 3 in Generation R, age 4 in ALSPAC) and with different measures (Child Behavior Checklist in Generation R, Strengths and Difficulties Questionnaire in ALSPAC).

Finally, prenatal maternal distress may confer a general, rather than specific, risk for psychopathology, as proposed in animal and human studies (Huizink & De Rooij, 2018; Huizink et al., 2004). For example, children of mothers who experienced stress during pregnancy appear to be at increased risk for a host of psychiatric conditions, not just ADHD. This could be an example of multifinality, the idea that different end states can be reached from a shared risk factor. Additionally, prenatal maternal stress has been associated with maternal malnutrition and substance use, which are also risk factors for ADHD (Huizink & De Rooij, 2018). Thus, these confounders should be carefully considered in studies on the relationship between prenatal maternal distress and ADHD in offspring.

9.2.2 Maternal Physical Health

9.2.2.1 Maternal Nutrition

Numerous studies have explored the association between prenatal maternal nutrition and ADHD in offspring (Borge et al., 2021; Cortés-Albornoz et al., 2021; Li et al., 2019), yielding inconclusive results. For example, a systematic review and meta-analysis of 17 studies with samples of children from the United Kingdom, France, Spain, Denmark, the Netherlands, Norway, New Zealand, Japan, Brazil, and Mexico evaluated ADHD risk based on maternal dietary patterns during and before pregnancy (Li et al., 2019). In these studies, ADHD was defined using the following outcomes: diagnosis, positive screen, and symptoms. These studies reported differing results that provided little convincing evidence of an association between maternal folate, multivitamin, polyunsaturated fatty acid, or seafood consumption and ADHD risk.

Folate (vitamin B9) has been of particular interest to researchers due to its critical role in pregnancy, specifically cell growth and development (e.g., neural tube formation; Blom et al., 2006). A recent systematic review and meta-analysis showed that prenatal supplementation of Folic Acid positively impacted neurodevelpmental outcomes and reduced risk for ADHD in offspring (Chen et al., 2023). Others, however, have shown no association between B vitamins (e.g., vitamin B12) and ADHD risk in offspring (Sourander et al., 2021). More broadly, Li et al. (2019) found that maternal western dietary patterns (i.e., consuming too many processed snack foods that are high in fat and sugar) and healthy maternal dietary patterns (i.e., consuming enough fruits, vegetables, fish, and whole grains) during the prenatal period were positively and negatively associated with ADHD risk, respectively, but this result was only significant in extreme cases (i.e., mothers in the highest quartile of western dietary patterns and the lowest quartile of healthy dietary patterns) and in children with co-occurring conduct problems. This has since been replicated in a recent study documenting a significant negative association between maternal diet quality and offspring ADHD symptoms as well as offspring ADHD diagnosis, along with a significant positive association between maternal consumption of ultra-processed foods and offspring ADHD symptoms in adjusted analyses (Borge et al., 2021; $N = 102{,}152$, age = 2–13 years).

9.2.2.2 Gestational Anemia

Estimated to affect over 40% of pregnancies, gestational anemia, a form of iron deficiency, is a global issue (WHO, 2008). Iron demands increase drastically during pregnancy, which requires mothers to produce enough red blood cells for the fetus and placenta and to prepare for blood loss during childbirth (Bothwell, 2000). Wiegersma et al. (2019; $N = 532, 232$) found a significant positive association (adjusted odds ratio [aOR] = 1.48; aOR = 1.37) between gestational anemia diagnosed during the first 30 weeks of pregnancy and ADHD in offspring, occurring alone *or* together with autism spectrum disorder (ASD) and/or intellectual disability (ID), in 6–29-year-old individuals. Preterm birth was the strongest mediator of this association. However, gestational anemia was not significantly associated with ADHD when an anemia diagnosis >30 weeks, a mutually exclusive ADHD group (i.e., children with ADHD alone), or discordant sibling pair data, meant to control for genetic confounding, were considered in analyses. Results were mixed when the timing of anemia diagnosis was not considered. Questions have been raised about an association between gestational anemia and ADHD in offspring since gestational anemia is also associated with prenatal maternal depression but is rarely included in analyses as a potential confounder (Andrade, 2020). Thus, to clarify the etiological role of gestational anemia in ADHD, the relationship between gestational anemia and prenatal maternal depression should be further explored.

9.2.2.3 Pre-pregnancy Maternal BMI and Obesity

Pre-pregnancy maternal BMI and obesity have been significantly positively associated with multiple neurodevelopmental disorders in offspring, including ADHD (Sanchez et al., 2018). A systematic review and meta-analysis by Jenabi et al. (2019) found that children of mothers whose pre-pregnancy BMIs were classified as "overweight" or "obese" had an increased risk of clinically elevated ADHD symptoms (28% and 42% higher, respectively) compared to children of mothers whose BMIs were classified as "healthy." These associations were no longer significant when only teacher-reported ADHD symptoms were used. The dose-dependent fashion of this association has been replicated by other studies. For example, in a Danish cohort study (Andersen et al., 2018; $N = 81{,}892$, mean age = 13.3 years), point estimates increased with BMI classification; children of mothers whose BMIs were classified as "severely obese" had the highest risk of combined-type ADHD as defined by diagnosis and medication use (hazard ratio [HR] = 2.19; adjusted hazard ratio [aHR] = 1.95), followed by children of mothers whose BMIs were classified as "obese" (HR = 1.57; aHR = 1.47), and children of mothers whose BMIs were classified as "overweight" (HR = 1.34, aHR = 1.28). This pattern was similar for children with inattentive and hyperactive-impulsive presentations of ADHD, children born preterm, and children with a diagnosis of co-occurring ASD (van der Burg et al., 2017). Inflammation has been posited to be a mediator of this association, although this has yet to be confirmed (Gustafsson et al., 2020; Shook et al., 2020).

The association between pre-pregnancy maternal BMI and ADHD risk in offspring has been speculated to be the result of confounding variables (Musser et al., 2017). For example, a systematic review, meta-analysis, and quasi-experimental family-based study by Li et al. (2020) found that the increased risk of ADHD, calculated with information on diagnosis, medication use, and symptoms, among children of mothers whose BMIs were classified as "overweight" and "obese," attenuated considerably, eventually becoming non-significant with adjustment for measured and unmeasured confounders. In other words, risk was highest in crude analyses (HR = 1.30, HR = 1.92), decreased when measured confounders (e.g., child's birth order, maternal education, cohabitation with the child's father at childbirth) were added to models (HR = 1.21, HR = 1.60), and was lowest when unmeasured familial confounders shared by cousins were added to models, with most results being non-significant (HR = 1.10 [NS], HR = 1.44) and siblings (HR = 1.01 [NS], HR = 1.10 [NS]).

9.2.2.4 Hypertensive Disorders and Preeclampsia

Hypertensive disorders, characterized by clinically elevated blood pressure, affect approximately 10% of pregnancies (Roberts et al., 2005). The presence of these disorders, particularly preeclampsia, has been related to ADHD risk in offspring (Gumusoglu et al., 2020; Lu & Hu, 2019; Pohlabeln et al., 2017). For example, the presence of maternal prenatal hypertensive disorders was associated with a higher risk of ADHD diagnosis in offspring in a UK cohort study involving 13,192 7-year-old children (Böhm et al., 2019). Additionally, a large Swedish cohort study ($N = 2{,}047{,}619$; age ≥ 3 years) found a significant positive association between preeclampsia and ADHD diagnosis in offspring, which persisted after potential environmental and genetic cofounders were considered via a sibling-controlled design (HR = 1.15; Maher et al., 2020). In this study, there was a stronger association between ADHD diagnosis and preeclampsia combined with a small gestational age than preeclampsia alone. Thus, shared placental pathology between preeclampsia and small gestational age has been posited as a mediator of this association. However, some studies have failed to find significant associations between other forms of gestational hypertension and ADHD in offspring (Amiri et al., 2012; Roigé-Castellví et al., 2021), potentially due to small samples of mothers with preeclampsia and/or a lack of adjustment for potential confounders.

9.2.2.5 Maternal Diabetes

Diabetes refers to a group of autoimmune diseases defined by high blood glucose. For some individuals, diabetes is first diagnosed during pregnancy, at which point it is referred to as "gestational diabetes." In their systematic review and meta-analysis, Yamamoto et al. (2019) found a pooled adjusted HR of 1.36 for ADHD diagnosis when children were exposed to pre-existing maternal diabetes. This finding replicates that of other studies, including a systematic review and meta-analysis by Guo et al. (2020), that have found pre-existing diabetes to be of more concern than gestational diabetes (Rowland & Wilson, 2021; Zhu et al., 2021). In terms of proposed mechanisms, high blood glucose has been linked to inflammation, which may alter the course of neurodevelopment (Sousa et al., 2017). Additionally, the risk of ADHD seems especially high in mothers who are obese and diabetic and in children who have conduct disorder (CD). For example, in adjusted analyses, pre-existing diabetes with severe obesity raises point estimates for HRs from 1.88 to 6.03 in children with ADHD and conduct disorder (Kong et al., 2018; $N = 649{,}043$, age ≤ 11 years). In this study, gestational diabetes in all BMI categories ("healthy" to "severely obese") was also associated with an increased risk of ADHD, but not nearly as much.

9.2.3 Maternal Medication and Substance Use

9.2.3.1 Antidepressants and Other Neuropsychiatric Medications

There has been conflicting evidence for an association between prenatal maternal antidepressant exposure and ADHD in offspring, with one systematic review providing evidence of a significant positive association (Rommel et al., 2020) and another finding no association (Kim et al., 2020). In a large sample of 6744 5-year-old children, Lupattelli et al. (2021) found no difference in the rate of ADHD diagnosis, medication use, or symptoms based on prenatal exposure to SSRI/selective norepinephrine reuptake inhibitors (SNRIs). Interestingly, this study also found that ADHD risk was *lower* in children of depressed mothers who were exposed to antidepressants compared to children of depressed mothers who were never exposed to antidepressants when outcomes were obtained early in childhood, and that ADHD risk was *higher* in children exposed to antidepressants than in non-exposed children when outcomes were obtained later in childhood. One possible explanation for this effect is that antidepressant exposure could mediate the association between prenatal maternal anxiety/depression and ADHD in offspring. However, the inverse could also be true, as maternal anxiety/depression prior to pregnancy has been associated with offspring ADHD. Other studies have found no association between other neuropsychiatric medication use (e.g., antipsychotics, most anti-epileptic drugs), although valproate—which has been documented to have neurodevelopmental effects—was an exception (Christensen et al., 2019; Wang et al., 2021). In terms of maternal psychostimulant use during pregnancy and offspring ADHD, the literature is relatively sparse. One study examined the relation between maternal ADHD medication use and offspring ADHD diagnosis or medication use, finding a significant positive association (aHR $= 1.96$) in the full sample (Lemelin et al., 2021; $N = 166{,}047$, offspring age ≥ 3 years). Yet, subgroup analyses in pregnant mothers with ADHD and siblings of the children failed to reach significance, suggesting that the overall analysis was affected by familial confounding.

9.2.3.2 Caffeine, Alcohol, and Smoking

The effects of commonly ingested legal substances like caffeine, alcohol, tobacco, and cannabis on neurodevelopment during the prenatal period have received considerable attention in the literature (Berglundh et al., 2021; Mamluk et al., 2020; Polanska et al., 2015; Robbins et al., 2021; Zhang et al., 2022). Tobacco smoking appears to have the strongest association with risk for ADHD, while caffeine, alcohol, and cannabis smoking appear to have relatively weaker associations, if any (Kim et al., 2020; Linnet et al., 2003).

With regard to smoking, a meta-analysis by Dong et al. (2018) found a significant positive association between maternal smoking during pregnancy, maternal smoking cessation during the first trimester, and ADHD diagnosis or symptoms in offspring after adjusting for potential confounders (i.e., parental psychiatric history and socioeconomic status [SES]). Notably, there was no association between increased risk for offspring ADHD and maternal smoking cessation *before* pregnancy, and there was inconsistent evidence pertaining to the risk of paternal smoking. Risk was also moderated by geographic region, with significant positive associations in American, European, and Australian samples but not in Asian samples (Dong et al., 2018). In a survey-based study of 19,940 parents, Han et al. (2015) found a significant positive association between maternal exposure to alcohol and tobacco smoke during pregnancy and ADHD symptoms in elementary-aged offspring. Specifically, children exposed to alcohol during pregnancy were 1.55 times more likely to have ADHD, while children exposed to maternal smoking during pregnancy were 2.64 times more likely to have ADHD, as compared to those who were not exposed to alcohol or smoking, respectively. There was no effect of paternal smoking during pregnancy on ADHD risk. However, among children of mothers who did not smoke, exposure to paternal smoking and alcohol during pregnancy increased the risk of ADHD the most (Han et al., 2015).

It is possible these associations could be due to unmeasured familial confounding. A meta-analysis by Haan et al. (2022) using data from three cohort studies, all of which employed a negative control and polygenic risk scores to account for potential environmental and genetic confounders, generally did not support a causal effect of maternal caffeine, alcohol, or smoke exposure in the prenatal period on ADHD risk in offspring, although there was sample-to-sample variability in the significance of results, with smoking being the most likely to have an effect. Other studies have reported similar results; two found that low-to-medium caffeine and alcohol intake had no association with ADHD risk in systematic reviews and meta-analyses (Li et al., 2019; San Martin Porter et al., 2019). However, extremely high intakes of caffeine and binge drinking/drinking in all trimesters of pregnancy were associated with increased risk for ADHD among offspring, though consideration of confounding effects is critical, as the associations became non-significant after adjusting for potential confounders including lower SES, more smoking, and increased hyperactivity in parents (Linnet et al., 2009; Pagnin et al., 2019).

Regarding cannabis, a systematic review by Roncero et al. (2020) presents emerging evidence of an association between prenatal maternal use, offspring ADHD symptoms, and offspring performance on a broad range of neuropsychological assessments tapping domains known to be impacted in many children with ADHD. However, performance on these assessments has been associated with other psychiatric conditions, making findings difficult to interpret in terms of specific to ADHD per se. Corsi et al. (2020; $N = 497{,}821$, age ≥ 4 years) found no association in adjusted analyses. However, this study focused only on ADHD co-occurring with conduct disorder, again leading to questions about specificity. Further research in this area is needed.

9.2.3.3 Opioids, Cocaine, and Methamphetamine

The effect of illicit drugs, including opioids, cocaine, and methamphetamine, on neurodevelopment has been extensively studied (Wanner et al., 2019), although research on ADHD specifically is more limited. A meta-analysis by Schwartz et al. (2021) found a significant positive association between prenatal maternal opioid exposure and hyperactive-impulsive symptoms ($d = 1.40$), inattentive symptoms ($d = 1.35$), and combined symptoms ($d = 1.27$) in children. The association was significant in both preschool ($d = 0.83$) and school-aged children ($d = 1.45$; 1.57 after removal of low-quality studies) and was stronger than that in two comparison groups: (1) children of mothers who never used opioids during pregnancy ($d = 1.35$; 1.27 after removal of low-quality studies) and (2) children reared by a father who used opioids or children raised in a household that qualified as low socioeconomic status or with environmental deprivation/neglect ($d = 1.02$). However, this association appears to weaken but remains significant when use of other substances is accounted for (see below, Garrison-Desany et al., 2022; $N = 3138$, age = 6 months to 21 years). Several studies have found associations between prenatal maternal cocaine and methamphetamine exposure and performance on neuropsychological assessments (e.g., higher reaction times, more mistakes made), but these results are not specific to ADHD (Kiblawi et al., 2013; Morrow et al., 2009; Smith & Santos, 2016), and other studies have not found associations between maternal opioid, cocaine, and methamphetamine exposure and ADHD in offspring (LaGasse et al., 2012; Linares et al., 2006; Trønnes et al., 2021).

9.2.3.4 Polysubstance Use

Few studies on the association between prenatal maternal substance use and ADHD in offspring have measured polysubstance use (i.e., simultaneous exposure to two or more drugs). In a recent cohort study, Garrison-Desany et al. (2022; $N = 3138$, offspring age = 6 months to 21 years) investigated the association between maternal use of any four substances—alcohol, opioids, and smoking (cannabis and tobacco)—during the prenatal period and ADHD diagnosis in offspring. In terms of single use, the adjusted point estimate for opioid use was highest ($HR = 2.19$), although this association attenuated when other substances were considered ($HR = 1.60$), and interactions between opioids and alcohol, cannabis, and tobacco were found ($HR = 1.15$, $HR = 1.42$, $HR = 1.17$). In terms of multiple use, ADHD risk increased by 21% with each additional substance used. Prenatal maternal exposure to opioids and tobacco smoking were independently significantly associated with ADHD diagnosis when considering other substances being used at the same time, while no significant effects of cannabis or alcohol were found. Moreover, children exposed to both cannabis and opioids had a 23% greater risk of ADHD compared to children exposed to each substance on its own. Notably, cocaine and methamphetamine were not included in this study. Thus, more extensive studies of polysubstance use are needed.

Possible mediators of these associations include changes to brain structure and function, specifically systems implicated in reward (Müller et al., 2013), decision-making (Burden et al., 2010), and working memory (Schweitzer et al., 2015), among other cognitive processes (Sirnes et al., 2017). However, numerous potential confounders could underlie these associations. For example, these substances have also been associated with maternal physical health outcomes (e.g., maternal hypertension; Zhang et al., 1999), as well as shared environmental and genetic factors (Schwartz et al., 2021; Wimberley et al., 2020).

9.2.4 Maternal Exposure to Environmental Toxins

9.2.4.1 Lead

Lead is a naturally occurring element found in small amounts in the earth's crust. It has been widely used in a variety of products and may be found in and around our homes, such as ceramics, pipes and plumbing materials, paint, gasoline, batteries, and so on. This widespread use has resulted in environmental contamination, leading to human exposure and health problems (Tong et al., 2000). Findings related to associations between maternal prenatal lead exposure and ADHD symptoms in offspring are somewhat inconsistent, with some studies finding positive associations with hyperactivity (Sioen et al., 2013), as well as associations with general neuropsychological functioning (i.e., attention, cognitive flexibility, planning, response inhibition, and working memory) in mid-childhood (Eubig et al., 2010; Neugebauer et al., 2015). However, other studies have not found significant associations between prenatal maternal lead exposure, executive functioning, and ADHD-related behavioral difficulties in mid-childhood (Boucher et al., 2012; Fruh et al., 2019). Prenatal lead exposure may alter neurotransmission (e.g., dopaminergic signaling), as shown through animal studies (Szczerbak et al., 2007).

9.2.4.2 Mercury

Similar to lead, mercury is a neurotoxic contaminant with known effects on neurodevelopment (Barbone et al., 2019). Prenatal maternal exposure to mercury has been positively associated with both inattentive and hyperactive-impulsive symptoms (Boucher et al., 2012; Sagiv et al., 2012). There is some evidence of sex effects, with this association being stronger in males than females. There is also evidence of source dependence. Specifically, in a meta-analysis by Yoshimasu et al. (2014), an association between ADHD diagnosis in offspring and prenatal environmental mercury exposure, but not clinical mercury exposure (thimerosal-containing vaccines, which contained ethyl mercury and are no longer available in the United States), was found. However, low-level exposure to environmental mercury has not been associated with ADHD in offspring (Patel et al., 2019).

9.2.4.3 Polychlorinated Biphenyls (PCBs)

PCBs are highly toxic industrial compounds that were once mass-produced to be used in various industrial and commercial settings. The production of PCBs was terminated in the United States in 1977 due to its adverse effects on human health (Agency for Toxic Substances and Disease Registry, 2021). Although PCBs are no longer produced in the United States and some other locations around the globe, humans may still be exposed to them through the use of old fluorescent lighting fixtures, old electrical appliances such as refrigerators and televisions, and other equipment that may have been produced before the manufacturing of PCBs was terminated. Small quantities may be released into the air when such equipment heats up. Additionally, humans may be exposed to PCBs through contaminated food (sportfish caught in contaminated waters, meat, and dairy products) and contaminated air

(Registry, 2021). If ingested, PCBs are easily absorbed, and because they are difficult to metabolize, they can persist in fat tissues and human breast milk (Lackmann et al., 2004).

Findings regarding the association between prenatal maternal exposure to PCBs and ADHD in offspring have been mixed. For example, PCB-135 concentrations at birth have been associated with ADHD, although with some caveats (i.e., in extreme cases; Verner et al., 2015). In a systematic review by Eubig et al. (2010), there was evidence of an association between prenatal maternal PCB exposure and ADHD-related behaviors in offspring. However, prenatal PCB exposure was not associated with ADHD symptoms in Inuit children within Arctic Québec (Boucher et al., 2012).

9.2.4.4 Air Pollution and Other Commonly Encountered Toxins

Among other environmental toxins, a systematic review by Myhre et al. (2018) found general and specific evidence of an association between prenatal maternal air pollution exposure and ADHD in offspring. However, a Swedish study found no such association (Oudin et al., 2019). Additionally, fluoride (Bashash et al., 2018), household inhalants (Fang et al., 2019), bisphenol A (Rochester et al., 2018), perfluorooctane sulfonic acid (Vuong et al., 2021), and perfluorononanoic acid (Vuong et al., 2021) have been found to be positively associated with ADHD, although evidence is mixed (Skogheim et al., 2020) and limited.

9.3 Perinatal and Childbirth-Related Factors

In addition to prenatal risk factors, perinatal and childbirth-related factors have also been linked to ADHD. Preterm birth and/or low birth weight, breech/transverse presentation, cesarean delivery, and a 5-minute Apgar score < 7 are among the strongest pregnancy- and childbirth-related risk factors for ADHD (Kim et al., 2020). History of miscarriage, head circumference at birth, and orofacial clefts have also been suggested to be risk factors, but research in these areas is still nascent (Carlsson et al., 2021).

9.3.1 Parental Age at Childbirth

Lower parental age at childbirth appears to be associated with a higher risk of ADHD in offspring (Min et al., 2021). A study from Denmark using data collected from nearly one million children found a significant negative association between parental age at childbirth and ADHD diagnosis in offspring (Hvolgaard Mikkelsen et al., 2017; 5 years). This association remained, weakening only slightly, after adjusting models for potential confounders (i.e., parity, smoking history, gender, and birth year). Children born to parents $\leq$20 years at the time of birth were more likely to be diagnosed with ADHD than children with parents aged 26–30 years at the time of birth, while children with a mother or father $\geq$31 years at the time of birth were less likely to be diagnosed than children with parents 26–30 years. Children with a young mother and father had the highest likelihood of being diagnosed with ADHD. Follow-up analyses on full and half siblings revealed that, in the full sibling sample, *older* mothers (i.e., $\geq$31 years) were still less likely to have a child with ADHD compared to those ages 26–30 years. However, there was no longer an association between *younger* maternal or paternal age and ADHD in full or half-sibling samples. There was also no longer a combined effect of parental age on half-siblings. Young parents could have increased susceptibility to ADHD and display sub-threshold behaviors (e.g., riskier sexual behaviors) that increase the risk of having a child at a younger age (Hua et al., 2021; Owens & Hinshaw, 2020; Shoham et al., 2021).

9.3.2 Prematurity and Low Birth Weight

A meta-analysis of 34 studies performed by Franz et al. (2018) found that children born very preterm (<32 weeks) and with very low birth weight

(<1500 g), as well as children born extremely preterm (<28 weeks) and with extremely low birth weight (<1000 g), had a higher risk of ADHD when a categorical definition was used for diagnosis (OR = 3.04). These risk factors were also associated with higher levels of dimensional ADHD symptoms (inattention [SMD = 1.31], hyperactivity and impulsivity [SMD = 0.74], combined [SMD = 0.55]). When birth weight was used as a continuous variable, the effect was still significant but attenuated (Momany et al., 2018). This association appeared to depend on a number of sample and measurement characteristics, including sample type (birthweight-based, ADHD-based, population-based, or community-based), geographic region (i.e., the continent from which the participants were recruited), ADHD informant type (clinician, parent, teacher, self, multi-informant), and birthweight measure type (medical record, parental report, self-report, multiple methods). Jackson and Beaver (2015; offspring age = 5–12 years) used a sibling-matched design and found a positive association between low birth weight and ADHD symptoms, which was mediated by changes in the dopaminergic system. Indeed, this has also been shown in a study examining low birth weight in a sample of Japanese children, in which only those with low birth weight and high genetic risk for ADHD had elevated inattention (relative risk [RR] = 1.56) and hyperactivity (RR = 1.87) symptoms (Rahman et al., 2021; $N = 796$, offspring age = 8–9 years).

Preterm birth has also been linked with a two-to-five-fold increased likelihood of ADHD, with the inattentive presentation being the most commonly linked to preterm birth (Bhutta et al., 2002; Halmøy et al., 2012; Johnson et al., 2010; Lindström et al., 2009; Perapoch et al., 2021; Perricone et al., 2013; Singh et al., 2013). It has been hypothesized that typical maturational processes of the brain are impacted in infants born preterm and, as a result, may disrupt cortical development and brain connectivity (Ball et al., 2012; Inder et al., 2005; Kapellou et al., 2006; Volpe, 2009). Such factors, along with other environmental factors associated with both preterm birth and ADHD (e.g., parental stress and psychopathology, social adversity, early institutional care), may put a child at increased likelihood for later ADHD symptoms (Pisoni et al., 2020; Shapiro et al., 2013; Wadhwa et al., 2001). For example, in a Spanish sample ($N = 7488$), Perapoch et al. (2021) found a negative association between the prevalence of ADHD and gestational age. The prevalence of ADHD in infants born at or before 28 weeks was 12.7%, compared to 3.2% for infants born after 37 weeks. These results have been supported by other studies examining the association between gestational age and symptoms of ADHD (for a meta-analysis, see Franz et al., 2018). However, most studies do not address whether this association is attributable to genetic and other environmental factors. This gap was filled in a recent study (Ask et al., 2018) that showed an association between early preterm birth (at 22–33 weeks) and later ADHD symptoms (mainly inattentive symptoms) after accounting for genetic and environmental factors shared within families (e.g., multiple birth status, sex, being small for gestational age, serious congenital malformations, mental stress, and education). Overall, these results highlight an association between preterm birth and an increased risk of developing ADHD and also illustrate that preterm birth may differentially affect inattentive versus hyperactive-impulsive symptoms in children.

9.3.3 Method of Delivery and Labor Induction

Several studies have examined methods of delivery and the risk of ADHD. For example, in a 2016 cohort study (Curran et al., 2016b) that included all singleton live births in Sweden from 1990 to 2008 ($N = 1{,}722{,}548$; $N = 47{,}778$ with ADHD), there was an association (albeit small) between birth by Cesarean sections and risk for ADHD. However, among siblings, this association was only present for emergency Caesarean sections, suggesting there may be other confounding variables explaining this association. That is, if there was a causal link between Cesarean sections and ADHD, this effect would also be expected for elective Cesarean sections. However, in other cohort studies, researchers have not found associations between method of delivery and ADHD in adjusted analyses (Curran et al., 2016a; Silva et al., 2014). Studies examining associations between labor induction and ADHD have also not found conclusive evidence suggesting a causal link between the two. For example, a recent meta-analysis of seven studies (three case-control and four cohort) showed that labor induction was not associated with a heightened risk for ADHD in children (Jenabi et al., 2021). However, because of concerns regarding potential neurodevelopmental risks associated with perinatal exposure to synthetic oxytocin often used for labor induction or augmentation (Kurth & Davalos, 2012; Kurth & Haussmann, 2011), more research is needed to both contextualize and generalize these findings in terms of potential dose-dependent effects of oxytocin on the risk of ADHD.

9.3.4 Postnatal Factors

9.3.4.1 Exposure to Environmental Toxins

Lead As noted previously, lead is an inorganic element with documented neurotoxic effects that can contaminate residences, food and water resources, and consumer products (Lidsky & Schneider, 2003). Even low levels of lead in the blood have been associated with intellectual, behavioral, and motor deficits in children (Sanders et al., 2009; Schnur & John, 2014). While there is currently no safe threshold for lead exposure, prolonged direct exposure to lead is linked with increased severity of ADHD symptoms (Vorvolakos et al., 2016).

Many studies have specifically focused on understanding the impact of *direct* lead exposure on the child and the presence of ADHD symptoms (He et al., 2019; Huang et al., 2016; Nigg et al., 2008). For example, in a cross-sectional study (Huang et al., 2016), blood lead levels in Mexican children ($N = 412$; 6–13 years) with low exposure (<5 μg/dL; micrograms of lead [μg] per deciliter of blood [dL]) to lead were positively linked with hyperactive/impulsive behaviors but not with inattention, as measured by the Connor's Rating Scale-Revised (Conners, 2001). These results were supported by a study of 8–17-year-old children, which found that blood lead levels were significantly higher in children with ADHD ($N = 150$) compared to those without ADHD ($N = 53$), and that blood levels were linked with hyperactivity/impulsivity but not inattentive behaviors (8–17 years; Nigg et al., 2008). The results of these studies are in agreement with other cross-sectional findings showing associations between direct lead exposure and the presence of ADHD symptoms in Korean ($N = 667$; 8–11 years; Cho et al., 2010) and Romanian samples ($N = 83$; 8–12 years; Nicolescu et al., 2010).

Other cross-sectional research has shown associations between blood lead levels and both inattentive and hyperactive-impulsive symptoms of ADHD (Lee et al., 2018; Nigg et al., 2008). For example, in a study conducted with 236 American children (6–17 years; 61 ADHD Combined presentation, 47 ADHD Inattentive presentation, 99 non-ADHD control, and 29 subthreshold/not otherwise specified), even low blood lead levels (<2.5 μg/dL) were associated with parent and teacher ratings of inattention and hyperactivity-impulsivity (Nigg et al., 2010). Similarly, Zhang et al. (2015) examined the association between lead exposure and ADHD symptoms in a Chinese population and showed that children ($N = 243$; 3–7 years) with high blood levels of lead (≥10 μg/dL) were 2.4 times more likely to meet DSM-IV criteria for ADHD (as measured by the Chinese version of the ADHD Rating Scale) than those with low blood levels of lead (≤10 μg/dL).

Finally, in a prospective cohort study, Ji et al. (2018) found that children in the Boston Birth Cohort ($N = 1479$; 299 ADHD, 1180 control) with early life blood lead levels between the range of 5–10 μg/dL had a 66% increased likelihood of receiving an ADHD diagnosis compared to those with <5 μg/dL blood lead levels (median age of ADHD diagnosis = 6 years). This association was stronger for males compared to females. Choi et al. (2016) also showed that, adjusting for potential confounder, such as residential area, household income, parental marital status, preterm birth, family history of psychiatric disorders, and low birth weight, symptoms of ADHD were more likely to develop in children with blood levels >2.17 μg/dL compared to children with blood lead levels below this threshold.

Together, these studies conducted across countries suggest that exposure to lead may be associated with both symptoms of inattention and hyperactivity-impulsivity and that higher blood levels of lead during early childhood may increase the likelihood of later developing ADHD symptoms.

Manganese According to the Centers for Disease Control and Prevention (CDC), manganese is a heavy metal found in groundwater, pesticides, batteries, and glass, among others. Young children are particularly vulnerable to higher levels of manganese exposure compared to adults because their central nervous system is not yet mature and, as a result, may be more susceptible to neurotoxins (Ljung & Vahter, 2007). Manganese exposure through drinking water has been associated with higher levels of manganese in hair and toenails (Bouchard et al., 2007; Ntihabose et al., 2018), which have been linked with a higher risk of neurodevelopmental disorders (Lucchini et al., 2018).

Recent research has shown that high levels of manganese may affect the dopaminergic system (Anderson et al., 2007; McDougall et al., 2008), and because dopaminergic transmission is suggested to contribute to the etiology of ADHD, some have investigated associations between elevated blood levels of manganese and ADHD symptoms. Because the therapeutic effect of methylphenidate (MPH) takes place mainly through inhibition of the dopamine transporter (DAT) in the striatum, one hypothesis is that elevated levels of manganese may disrupt the dopaminergic system in treatment naïve participants, thereby impacting the presentation of ADHD symptoms (Farias et al., 2010). To test this, one study compared blood levels of manganese between children (7–15 years) taking MPH and those who were treatment naïve, finding that blood levels of manganese were higher in those children with ADHD who were *not* taking MPH ($N = 74$) compared to those with ADHD who were on medication ($N = 32$) as well as control participants ($N = 35$). These findings suggest a relationship between elevated manganese exposure and ADHD symptoms and support the notion that higher manganese levels may impact the dopaminergic system in children showing symptoms of ADHD.

Another study examined exposure to manganese in everyday drinking water and its association with a diagnosis of ADHD. In a nationwide population-based registry study in Denmark (Schullehner et al., 2020), manganese measurements were collected from 82,574 drinking water samples to obtain longitudinal manganese exposure estimations during the first 5 years of life. This study had many limitations, including the post-hoc creation of DSM-oriented ADHD presentations from ICD-10 codes, despite the fact that the ICD does not specify such subtypes/presentations. After adjusting for confounding variables such as age, birth year, socioeconomic status, and urbanicity, results revealed that elevated levels of manganese in drinking water were linked with a greater risk for the constructed "Inattentive presentation," but not the constructed "Combined presentation." However, it should again be noted that these presentations do not actually conform to standard DSM-based presentations, which may explain the unusual finding of associations with the "Inattentive presentation" but not the "Combined presentation," despite the fact that by definition, these presentation types should have roughly equivalent levels of inattentive symptoms. Therefore, these findings should be interpreted with caution, and more research is needed to generalize the findings of these studies to larger populations across geographical locations.

Polychlorinated Biphenyls (PCBs) As previously noted, PCBs are banned industrial compounds that are neurotoxic in nature. Animal research has shown that exposure to PCBs may impact dopaminergic function, as measured by alterations in dopamine levels (Bemis & Seegal, 2004; Seegal et al., 2002). Because reduced cellular dopamine levels have been linked with ADHD (Tripp & Wickens, 2008), exposure to PCBs has been studied as one possible mechanism that may explain symptoms of ADHD. As reviewed in the previous section, while many studies have linked prenatal exposure to PCBs with attentional impairments in humans (for a review, see Boucher et al., 2009), some animal studies have shown that laboratory rats postnatally exposed to PCBs also show elevated levels of hyperactivity (Holene et al., 1998) along with deficits in response inhibition (Berger et al., 2001), and monkeys exposed to PCBs in the early postnatal period show difficulties during working memory tasks (Rice & Hayward, 1997). However, these animal model findings are somewhat inconsistent, as others examining effects on attentional processes in rats found very little impact (Bushnell et al., 2002).

Epidemiological studies examining associations between postnatal PCB exposure and activity and attention in humans have also yielded inconsistent findings (Jacobson & Jacobson, 2003; Plusquellec et al., 2010; Verner et al., 2010; Vreugdenhil et al., 2002). This may be due to methodological differences in terms of measuring exposure to PCBs during infancy and early childhood. For example, since obtaining repeated blood samples in infancy may not be practical, researchers often measure exposure to PCBs based on breast milk PCB levels as well as the duration of breastfeeding (Vreugdenhil et al., 2002) or, in some cases, blood measurements in later childhood (Jacobson & Jacobson, 2003). One study attempted to address such inconsistencies related to postnatal PCB exposure and later behavioral problems (Verner et al., 2015). Using a pharmacokinetic model, the authors examined monthly PCB levels in infants ($N = 441$; 1–12 months) based on parameters of breastfeeding and cord serum PCB levels. ADHD symptoms were assessed using the teacher-reported Conner's Rating Scale (CRS-T; Conners, 2001) at 8 years of age. The correlation between postnatal PCB exposure and ADHD symptoms at 8 years was weaker compared to the correlation between PCBs measured in cord serum at birth, which reflects maternal PCB exposure. The authors discuss these findings as inconclusive in terms of examining the potential adverse effects of postnatal PCB exposure in infancy on ADHD-related behaviors in later childhood. Nevertheless, the authors conclude that children with elevated ADHD-like behaviors at 8 years of age, with possible genetic predisposition and exposure to early-life environmental factors, may be susceptible to both prenatal and postnatal exposure to PCBs. Together, both animal and human studies highlight possible associations between exposure to PCBs and ADHD-related symptoms. However, further research is warranted, especially in examining low-level PCB exposure during early development and the later development of ADHD symptoms.

Organophosphate Pesticides (OP) Organophosphate pesticides (OP) are a class of insecticides that are used in agriculture and indoor settings, resulting in environmental pollution (Adeyinka et al., 2018). Humans may be exposed to OPs by working in places where these products are manufactured, touching contaminated soil or groundwater, or eating contaminated food. Acute exposure to OPs has been shown to have adverse health effects in humans (Eskenazi et al., 1999; Muñoz-Quezada et al., 2013; Sapbamrer & Hongsibsong, 2019), warranting exploration to understand the relationship between exposure to OPs and the presence of symptoms indicative of neurodevelopmental disorders in children. In particular, fetuses and young children have reduced amounts of OP detoxifying enzymes compared to adults (Furlong et al., 2006; Holland et al., 2006) and, as a result, are more vulnerable to OP exposures.

A Taiwanese study (Yu et al., 2016) sought to investigate the association between exposure to OPs and ADHD, adjusting for covariates (gender, parental education, maternal drinking during pregnancy, etc.), in 97 children with ADHD compared to 110 non-ADHD participants (4–15 years). OP exposure was measured via urinary levels of dialkylphosphate (DAP) metabolites which are biomarkers for OP exposure. Children in the ADHD group showed higher urinary concentrations of dialkylphosphate metabolites compared to the control group, suggesting exposure to OPs. In addition, children with exposure to OPs had a two- to threefold increased likelihood of receiving a diagnosis of ADHD. These findings are in agreement with another study that examined the association between urinary concentrations of dialkylphosphate metabolites of OPs and ADHD in 8–15-year-old children representative of the general population in the United States ($N = 1139$; Bouchard et al., 2010). Those with higher urinary concentrations of dialkylphosphate metabolites, particularly dimethyl alkylphosphate (DMAP), were more likely to receive a diagnosis of ADHD. Additionally, children with higher than median levels of dimethyl thiophosphate (commonly detected DMAP metabolite) showed twice the likelihood of being diagnosed with ADHD compared to children with undetectable levels.

In contrast to these findings, Marks et al. (2010) did not find a significant correlation between children's *postnatal* urinary DAP metabolite levels (measured at 3.5 [$N = 331$] and 5 [$N = 323$] years) and attention-related problems as measured by the Child Behavior Checklist (Achenbach & Rescorla, 2000), although *prenatal* exposure to OPs (measured in mothers at two time points during pregnancy) was related to children's CBCL-derived attention problems at 5 (but not 3.5) years of age. Similar findings were obtained by Eskenazi et al. (2007)—there was no association between concentrations of children's urinary DAP and Child Behavior Checklist attention problems in 2-year-old children ($N = 356$).

Although these findings provide a mixed picture regarding the risks associated with OPs in the context of ADHD, these studies indicate that OP exposure may, to some extent, contribute to the development of ADHD and that these associations may be more evident in older children, though more longitudinal research is needed to determine definitive causal relations.

Air pollution Air pollution is a mixture of particulate matter (PM), trace metals, adsorbed organic compounds, and gases released into the air. The most common sources of air pollution are burning fossil fuels, which release toxic gases and chemicals. Traffic-related pollution also contributes to global air pollution and leads to various health problems in cities with high amounts of traffic (Brunekreef & Holgate, 2002; Laumbach & Kipen, 2012; Mannucci et al., 2015). Recent studies have shown that even low levels of traffic pollution (i.e., below air quality limit values) may be detrimental to humans (Shi et al., 2016; West et al., 2016) and that young children are more vulnerable to toxic substances (Currie & Neidell, 2005; Currie et al., 2009) compared to adults.

While some studies have shown links between air pollution and symptoms of neurodevelopmental disorders like ASD and ADHD (Min & Min, 2017; Siddique et al., 2011; Thygesen et al., 2020), others have not found evidence of such associations (Gong et al., 2014). Some have argued that relatively low levels of air pollution may have contributed to the absence of an association between air pollution and neurodevelopmental disorders in certain locations like Sweden (Gong et al., 2014) compared to similar studies conducted in other parts of the world with higher amounts of air pollution (Min & Min, 2017; Siddique et al., 2011). However, this argument was not supported in a Danish study (Thygesen et al., 2020) that showed positive associations between air pollution and increased risk for ADHD despite lower general levels of air pollution.

One study conducted in the Netherlands showed that continued exposure to traffic-related air pollution negatively impacted cognitive functioning in 9–11-year-old children ($N = 553$) while adjusting for socio-economic and lifestyle factors (Van Kempen et al., 2012). These results were supported by a Spanish study (Sunyer et al., 2015) showing links between high levels of traffic-related air pollution and reductions in cognitive development over a 12-month period of time in 7–10-year-old children ($N = 2715$), also adjusting for covariates such as age, sex, maternal education, socioeconomic status, and air pollution at home. In a cross-sectional study conducted in India (Siddique et al., 2011), the authors examined whether prolonged exposure to traffic-related air pollution impacts behavior and activity levels in children. This was achieved by examining the prevalence of ADHD in children ($N = 969$; 9–17 years) living in urban areas compared to age- and sex-matched children from rural areas ($N = 850$). The prevalence of ADHD was higher in the urban population compared to rural children, and higher levels of air pollution with respect to PM with a diameter < 10 μm (PM_{10}) were a primary risk factor associated with the risk for ADHD, among several others (i.e., being male, lower socioeconomic status, 12–14-year age range). Even after controlling for covariates such as age, gender, socioeconomic status, and parental smoking, ambient particulate matter (PM_{10}) was positively associated with ADHD.

These findings have been supported by studies conducted in other countries (Min & Min, 2017; Newman et al., 2013; Thygesen et al., 2020). For instance, a Korean study (Min & Min, 2017) found a positive association between cumulative exposure to air pollutants (i.e., PM_{10} and Nitrogen dioxide [NO_2]) from birth to 10 years of age and ADHD diagnosis in children ($N = 8936$; 314 with ADHD). Additionally, higher levels of air pollution have been related to a two- to threefold increased risk for ADHD (Min & Min, 2017). Similarly, Newman et al. (2013) found that exposure to elemental carbon during the early years of life was linked with greater hyperactivity scores in 7-year-old children in the United States. Because strong associations have been found between air pollution and the risk of ADHD, many have suggested that efforts should be taken to reduce the overall emissions of pollutants into the air. Finally, given that air pollution involves a mixture of multiple pollutants, systematic research is needed to examine the role of various air pollutants as risk factors for ADHD.

9.3.4.2 Psychosocial Factors

Socioeconomic Status (SES) Socioeconomic status (SES) broadly refers to one's social and economic position with respect to the ability to create or consume goods that are valued in the larger society, as well as the possession of tangible belongings (Miech & Hauser, 2001). Many studies have linked socioeconomic adversity with poor health conditions throughout the lifespan (Chen & Miller, 2013; Mackenbach, 2012; Matthews et al., 2010; Reiss, 2013). In line with the multifactorial etiological characterization of ADHD, numerous studies have examined a range of SES-related variables (i.e., social adversity, early childhood deprivation, parenting styles, household environment, parental income, and parental education) in the context of diagnosis or risk for ADHD and have found links between low SES and an elevated risk for ADHD (Biederman et al., 2002; Kreppner et al., 2001; Larsson et al., 2014; Lawson et al., 2017; Mulligan et al., 2013; Pheula et al., 2011; Russell et al., 2016).

A nationwide population-based cohort study conducted in Sweden with over 800,000 children born between 1992 and 2000 showed that those born in households with overall lower income levels were at an increased risk for ADHD after controlling for co-occurring risk among siblings and cousins (Larsson et al., 2014). A recent systematic review on this topic also found that 35 out of 42 studies that were included in the review showed a significant association between one or more measures of socioeconomic adversity and an elevated likelihood of ADHD diagnosis (Russell et al., 2016). In particular, children in low-SES environment were 2.21 times more likely to receive a diagnosis of ADHD compared to children from relatively high-SES backgrounds. Additionally, children of parents with fewer educational qualifications, a variable associated with SES, were 1.91 times more likely to show symptoms of ADHD compared to children of parents with higher degrees (Russell et al., 2016). However, these studies did not account for family history of ADHD, which is an established risk factor for ADHD. This was addressed in a study by Rowland et al. (2018), which showed that without a parental history of ADHD, children from low SES backgrounds were 6.2 times more likely to show symptoms of ADHD compared to children from high SES backgrounds. Among children with a parental history of ADHD, however, SES played a weaker role. The conclusion is that, among children without a genetic predisposition for ADHD, environmental risk factors may play a bigger role and that parental history of ADHD may interact with SES, thereby modifying its impact.

Although there is strong evidence suggesting associations between measures of SES and ADHD, the mechanisms through which this association arises remain unclear. For example, parents with economic challenges have been shown to have less nurturing and engaged parenting styles compared to high SES families, likely because of limited resources in the family (Kiernan & Huerta, 2008). Such experiences early in development have long been known to impact the cognitive and emotional well-being of children (Duncan et al., 1994; Pollak et al., 2010). Diet is another possible factor that may mediate associations between SES and ADHD (McCann et al., 2007). Finally, Russell et al. (2016) showed that parental attachment or conflict in the family may partially influence the association between SES and ADHD. Together, these results suggest that lower SES and associated factors may be one of many risk factors that contribute to the development of the ADHD phenotype.

Extreme Early Deprivation Research has consistently linked ADHD to a history of extreme early deprivation (Kreppner et al., 2001; Sonuga-Barke & Rubia, 2008). Such extreme early deprivation was widely reported in Romanian orphanages and consisted of lack of physical, nutritional, psychological, and social care. Children in such orphanages lived in harsh physical conditions, were confined to their assigned spaces, lacked access to nutritious food, and had little personalized care (Castle et al., 1999; Kaler & Freeman, 1994; Kreppner et al., 2001). Kreppner et al. (2001) examined ADHD-related traits in 165 children adopted into the United Kingdom (UK) at various timepoints in their development (e.g., 0–42 months of age) following extreme early deprivation in Romania and 52 within-UK adopted children who were not exposed to deprivation. Results showed significant group differences in terms of symptoms of inattention and overactivity in children exposed to a longer duration (6–24 months) of early deprivation that was not accounted for by other factors such as malnutrition, weight at birth, and cognitive impairment. This impact of the duration of deprivation did not decrease over time. Additionally, symptoms of inattention and overactivity were also correlated with disturbances in attachment. Humphreys et al. (2020) showed similar results in that 136 children living in Romanian institutions (mean age = 22 months) were randomized into 'care as usual' (i.e., prolonged institutional care) or foster care settings. Caregivers completed psychiatric interviews reporting on past year diagnoses and symptom presentation at age 16. Results showed that, compared to the never-institutionalized individuals ($N = 47$), ever-institutionalized children showed greater rates of psychiatric disorders and higher externalizing, internalizing, and ADHD symptoms. Additionally, children in 'care as usual' (i.e., institutionalized) were twice as likely to have behavioral problems compared to children in foster care. Evidence of ADHD-related symptoms in post-institutionalized children has been supported in other studies (Gunnar & Van Dulmen, 2007; Rutter et al., 2001; Wiik et al., 2011), with results showing that during the middle childhood years, post-institutionalized children may be at an increased risk for ADHD compared to non-adopted children (Wiik et al., 2011). Such work has suggested that severe early deprivation may play a role in the development of high levels of inattention and hyperactive-impulsive behavior, which appear to persist, often in combination with attachment problems, through (Stevens et al., 2008) and into young adulthood (Kennedy et al., 2016). However, the generalizability of this phenotype to ADHD outside the context of severe early institutional deprivation remains a question.

Parenting Styles Parents play a crucial role in shaping children's behavior (Collins et al., 2000). A bidirectional/transactional model of parent-child interactions suggests that characteristics of ADHD in early childhood present several challenges to parents' ability to maintain stable and responsive parenting styles (Johnston & Jassy, 2007). For example, children's higher levels of impulsivity and inattention may increase parental demands in various situations and, as a result, may also increase the likelihood that parents may respond with less optimal parenting strategies such as overly harsh discipline, withdrawal from the situation, or lax parenting (Johnston & Jassy, 2007). While there is minimal evidence suggesting a causal link between parenting styles and ADHD, parent–child interactions may contribute to the maintenance of underlying symptomatology. For example, certain parenting styles emerging in response to a child's challenging ADHD-related behavior (i.e., high activity level and intensity, low effortful control) may exacerbate externalizing behavior patterns (Johnston & Mash, 2001; Johnston et al., 2012).

A large number of studies have investigated the relationship between parenting styles and symptoms of ADHD in children. For example, Keown and Woodward (2002) examined the quality of parent-child relationships and family functioning in 33 male children with early-onset hyperactivity compared to 34 male comparison participants (47–62 months). Results showed that greater levels of lax parenting styles, reduced parental coping, overactive parenting, decreased rates of father-child communication, and asynchronous mother-child interactions were linked with hyperactivity. After adjusting for the effects of child conduct problems and other confounding factors (e.g., children's verbal ability and age, parental education, income, age, number of children, number of negatively rated life events, and whether the child belongs to a single-parent family), overreactive parenting and mother-child communication were no longer significant. These results are supported by other studies showing differences in parenting styles among parents with and without ADHD (Yousefia et al., 2011) and showing similar associations between parenting styles and symptoms of ADHD (Allmann et al., 2022; Kaiser et al., 2011; Modesto-Lowe et al., 2008). However, not all studies have accounted for parental ADHD, which may impact parenting styles (Harvey et al., 2003; Park et al., 2017) and the likelihood of ADHD symptoms in children (Takeda et al., 2010).

This research gap was addressed by Ellis and Nigg (2009), who examined the association between ADHD in children ($N = 181$ [24 ADHD Inattentive Type; 71 ADHD Combined Type; 52 Non-ADHD Comparison; 34 ADHD not otherwise specified/borderline]; 6–12 years) and parenting styles while controlling for parental ADHD symptoms along with child oppositional defiant disorder (ODD) and conduct disorder (CD) diagnoses. Results indicated that inconsistent maternal discipline was linked with the ADHD Combined type even when controlling for child ODD and CD diagnoses and parental ADHD symptoms. Although low parental involvement was associated with ADHD irrespective of the subtype, when controlling for parental ADHD, this effect became marginal.

These studies do not indicate causal relations between parenting behavior and ADHD symptoms, and in fact, it is well established that parenting does not cause ADHD. However, the quality of parent-child relationships may contribute to the development and continuation of behavioral difficulties experienced by children, and these associations may not be fully attributed to parental ADHD. Findings also have implications for parent-based interventions focusing on optimizing parent-child interactions and improving parental coping strategies.

Electronic Media Exposure The amount of time children spend watching electronic media has skyrocketed in the last two decades (Chen & Adler, 2019). Prolonged exposure to screen time has been associated with reduced social behavior and language skills as well as increased inattention and hyperactivity behaviors in young children (Christakis et al., 2004; Lin et al., 2015; Stiglic & Viner, 2019; Wu et al., 2017). A small number of studies employing longitudinal designs have also shown that an increased amount of screen time may contribute to delayed developmental milestones in children (Madigan et al., 2019; Tomopoulos et al., 2010).

Several studies have examined the role of electronic media exposure in early childhood and ADHD-related behaviors. For example, using data from the Canadian Healthy Infant Longitudinal Development study, Tamana et al. (2019) found that children (N = 2322) who were exposed to screen time for more than 2 hours/day at 3 and 5 years of age were 5.9 times more likely to show clinically significant inattention problems as measured by the CBCL at 5 years compared to those with less than 30 minutes/day screen time exposure. Additionally, children with screen time of more than 2 hours/day were 7.7 times more likely to meet DSM-5 criteria for ADHD (N = 24). Similar results were found in a longitudinal cohort study in Japan that showed that children (N = 316) with prolonged exposure to screens at 18 months had increased hyperactivity and inattention symptoms at 30 months of age compared to children with low levels of screen time exposure (Cheng et al., 2010). Christakis et al. (2004) supported these findings by showing that increased screen time at 1 and 3 years of age in a community sample (N = 1345) was associated with attentional problems at 7 years, although this study did not use a standardized measure of ADHD.

In a cross-sectional study, Hill et al. (2020) showed that 36-month-old toddlers with increased ADHD-related symptoms (N = 120; 20 ASD; 14 elevated ADHD symptoms; 86 Comparison) spent more time watching electronic media compared to the comparison group, and the amount of screen time was not associated with family history of ASD or ADHD. Similar findings have also been observed in older populations. For example, Swing et al. (2010) showed an association between elevated screen time (TV plus video games) and higher attentional problems in school-aged children (N = 1323) as well as young adults (N = 210). However, contrary to the findings of these studies, Stevens and Mulsow (2006) did not find a strong association between exposure to screens at 5 years of age and symptoms of ADHD (measured using a non-standardized measure) at 6 years of age. Obel et al. (2004) also did not find an association between hours of screen time at 3.5 years and behavioral problems at 10–11 years.

Although intuitively appealing, the association between electronic media exposure and ADHD seems to be mixed. Methodological differences, including the use of non-standardized measures, may explain some of these contradictory findings. More research is needed to systematically examine the impact and timing of screen time exposure on behaviors such as inattention and hyperactivity. Nevertheless, given possible links between screen time and ADHD, the American Academy of Pediatrics recommends limiting the overall amount of electronic media exposure in early childhood (Brown, 2011; Strasburger et al., 2013).

9.3.4.3 Nutrition

The notion that certain foods may have a causal link to ADHD has been controversial, yet the topic continues to interest researchers as well as parents of children with ADHD who prefer to explore alternative strategies and/or complementary approaches to medication in particular. Several studies have examined the association between iron deficiency and ADHD symptoms. For example, Juneja et al. (2010) showed that iron levels were significantly lower in 6–14-year-old children with ADHD (N = 25) compared to children without ADHD (N = 25). These results were supported by Berner et al. (2014), who showed that both iron and vitamin D deficiency were strongly associated with ADHD in a sample of 630 children with ADHD compared to 630 control participants (5–18 years). In a longitudinal study, severe iron deficiency during infancy was linked to maternal ratings of externalizing and internalizing problems from 5 to 11–14 years of age in non-diagnosed children ($N = 185$; Corapci et al., 2010). Other studies, however, have failed to find associations between iron levels and ADHD-related symptoms (Kiddie et al., 2010; Menegassi et al., 2010). Studies examining zinc, copper, and omega-3 fatty acid levels have also revealed significant associations between copper, zinc, and omega-3 fatty acids and ADHD symptoms (Arnold & DiSilvestro, 2005; Hawkey & Nigg, 2014; Kiddie et al., 2010; Raz & Gabis, 2009; Richardson, 2006; Toren et al., 1996; Viktorinova et al., 2016).

Howard et al. (2011) further highlighted the association between diet and ADHD symptoms by following 1799 Australian children (115 of whom received a diagnosis of ADHD) from birth to 14 years, identifying an increased likelihood of ADHD diagnosis among children with "western" dietary patterns (i.e., consumption of more fat, sodium, and sugar, and reduced amounts of folate, omega-3 fatty acids, and fiber) after adjusting for known confounding factors. Similar findings were described by Ríos-Hernández et al. (2017), who examined the association between a Mediterranean diet and ADHD symptoms in children and adolescents and found a reduced frequency of consuming healthy foods such as fruits, vegetables, rice, and pasta, along with a greater frequency of skipping breakfast and consumption of fast food, was associated with ADHD diagnosis. Additionally, this study identified links between high consumption of soft drinks, candy, and sugar, along with low amounts of fatty fish, and a higher likelihood of ADHD diagnosis (Ríos-Hernández et al., 2017).

There is also some research suggesting an association between food additives and ADHD symptoms in children. Research on the effects of artificial food additives and colors began in the 1970s, investigating the hypothesis that artificial food dyes and salicylates may negatively impact children's overall behavior (Feingold, 1975). Feingold observed improvements in hyperactivity behaviors in more than 50% of children after eliminating artificial food dyes and products with naturally occurring salicylates. However, subsequent studies failed to support the Feingold hypothesis while identifying only a small subset of children with true sensitivities to food additives (Conners et al., 1976; Harley et al., 1978). Critics argue that Feingold may have overstated the link between food additives and hyperactivity and that methodological issues in the original studies necessitate caution when interpreting the findings. Since then, many studies have tested the Feingold hypothesis, primarily resulting in mixed findings (Cormier & Elder, 2007; Stevens et al., 2011).

9.4 Gene–Environment Interaction

The discussion of environmental risk factors would be incomplete without consideration of genetic factors associated with ADHD and the way such factors interact with the environment and context. Studies have shown the heritability of ADHD to be around 70–80% (Faraone & Larsson, 2019) and have identified a number of candidate genes that may play a causal role in the development of the ADHD phenotype (Forero et al., 2009; Li et al., 2006). However, as emphasized throughout this chapter, the etiology of ADHD cannot be solely explained by genes, with a growing number of environmental factors significantly associated with ADHD and its constituent symptoms. It is widely recognized that ADHD results from a complex interaction between an individual's genes and the surrounding environment. For example, Brookes et al. (2006) showed that the association between ADHD symptoms and a dopamine transporter gene (DAT1) polymorphism was stronger in children of mothers who drank alcohol during pregnancy, suggesting that certain environmental factors may moderate genetic risk. Another study found that the association between dopamine transporter (DAT) polymorphism and ADHD related to hyperactive-impulsive symptoms only in the context of exposure to prenatal maternal smoking (Kahn et al., 2003). Among children with ADHD who also had symptoms of conduct disorder, those who carried the COMT gene have been shown to be more susceptible to the negative impact of lower birth weight. More recent research supports these prior findings, showing that COMT and DAT1 polymorphisms moderate the indirect effects of parenting styles on ADHD symptoms (Morgan et al., 2018) and that positive parenting behaviors may moderate the genetic influences on childhood ADHD symptoms (Nikolas et al., 2015). These results indicate that certain genetic profiles may moderate the impact of environmental and contextual influences on the onset and course of ADHD symptoms by impacting one's sensitivity to various environmental risk factors. In other words, although ADHD may be largely explained by genetic factors, symptom development and maintenance can be impacted by environmental influences.

9.5 Protective Factors

As described throughout this chapter, prior studies have highlighted various risk factors associated with ADHD. However, equally important from a developmental psychopathology perspective are factors that may have protective effects on the clinical presentation of ADHD or that may promote resilience. What environmental or contextual influences might distinguish those who display adaptive developmental patterns and positive outcomes from those who experience negative outcomes? A recent study involving children and adolescents with ADHD ($N = 4122$) found that those exposed to higher levels of family cohesion and community support had a reduced likelihood of exhibiting moderate-to-severe ADHD symptoms (Duh-Leong et al., 2020). These findings build on earlier research showing links between family cohesion and reduced ADHD symptoms as well as the overall quality of life in individuals with ADHD (Dvorsky & Langberg, 2016). Research has also highlighted an association between positive community environments (e.g., presence of social networks, sense of safety, cooperation, and trust) and favorable outcomes among individuals with ADHD. For example, results based on the 2007 National Survey of Child Health showed links between supportive community environments and lower rates of ADHD diagnoses as well as milder ADHD symptom severity (Derauf et al., 2015; Razani et al., 2015). In contrast to the findings of prior studies, Wüstner et al. (2019) found that possible protective factors such as self-efficacy, social support, and family environment did not predict symptoms of ADHD at baseline based on their cross-sectional analysis ($N = 1384$; 11–17 years at baseline). However, in a longitudinal analysis spanning 2 years, improvements in the family environment over time were linked with reductions in ADHD symptoms. Finally, there is emerging evidence indicating that maternal breastfeeding may reduce the likelihood of ADHD symptoms in children (Zeng et al., 2020). A recent review and meta-analysis of studies published before May 2018 showed that children who were breastfed over 1, 3, 6, or 12 months had a lower risk of ADHD compared to children who were never breastfed. (Zeng et al., 2020). However, more research is needed to understand the causality of the relationship as well as any underlying mechanisms that may explain this association.

Overall, there is emerging evidence that family and community-based factors play a vital role in promoting positive outcomes among individuals with ADHD. Mental health providers, therefore, should consider focusing on identifying strong family- and community-based relationships as part of ADHD intervention strategies. Moreover, given the links between maternal breastfeeding and reduced risk for ADHD, health providers may wish to support new mothers in breastfeeding their infants when possible.

9.6 Summary and Future Considerations

The literature on environmental risk factors for ADHD is largely inconsistent, although there is stronger evidence for some factors (e.g., prematurity, low birth weight, parental age, maternal cigarette smoking, exposure to environmental toxins, extreme early deprivation) than others (e.g., maternal diet, method of delivery, screen time). Methodological variation should be taken into consideration when interpreting the results of these studies. For example, methodologically, most of these studies used self-report measures to obtain parent data and parent-report measures to obtain child data. Future studies should consider a multi-informant approach, incorporating measures from teachers and clinicians, in addition to parents and self-report, when feasible. Additionally, ADHD has been defined both categorically, in terms of diagnosis, and dimensionally, in terms of symptoms. When available, studies should consider performing analyses using both approaches. Studies should also discuss results in the context of the recruited samples, which are often homogenous and not adequately inclusive of individuals from diverse backgrounds. Further, studies should carefully consider how results are reported and interpreted. Many studies report point estimates with wide confidence intervals, with the lower bound just over 1. However, recent discussions have emerged surrounding the over-reliance on *p*-values over effect sizes. Future studies should continue to report both and consider effect sizes in the interpretation of findings. There is also large variation with respect to included covariates, which may impact findings. While some studies examine moderators and mediators of effects, not all do, but the inclusion of such analyses could be informative. Although some mechanisms relating different environmental factors to ADHD may be shared across prenatal and postnatal periods (e.g., shared genetic risk of ADHD or other psychiatric conditions such as depression), others may be distinct to each period, suggesting that more specificity in terms of timing of effects is needed. Finally, studies designed to address complex interactions between genetic and environmental factors will provide added value over those examining each in isolation.

In sum, ADHD is a complex and multifactorial condition. Although genetic influences are strong, it is clear that environmental factors are also influential. Continued research exploring interactions between genetic and environmental risk factors, along with protective factors, is likely to provide a more robust understanding of the disorder with potential directions for prevention and intervention.

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ADHD and Sleep Problems

10

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Introduction
The relationship between ADHD and sleep is an area of substantial research focus and clinical interest (Cortese et al., 2022). It has long been maintained that individuals with ADHD are more likely to have sleep problems. In fact, restless sleep was once a diagnostic criterion for ADHD (American Psychiatric Association, 1987). Furthermore, poor attention is one of the hallmark symptoms of sleep deprivation, and poor sleep is thought to be highly prevalent in individuals with ADHD across the lifespan. Despite this association, the exact nature of this relationship continues to be a topic of debate, with views ranging from directional causation (i.e., ADHD causing sleep problems or sleep problems causing ADHD) to bi-directional causation (i.e., one disorder leading to an exacerbation of the other and, in turn, exacerbating the primary diagnosis) to theories purporting that both ADHD and sleep problems are caused by a third underlying variable.

In Sect. 10.1 of this chapter, we review general information about sleep, and then review the evidence for differences in sleep in people with ADHD. In Sect. 10.2, we provide information about the assessment of sleep and explore how assessment may differ for people with ADHD. In Sect. 10.3, we provide information about the most common types of sleep disorders in individuals with ADHD, along with the recommended treatment for each sleep disorder. We also share how treatment might be modified for an individual with ADHD. Section 10.4 provides a case study of an adult with ADHD that highlights sleep problems across the lifespan. This case study allows the reader to integrate the information learned in this chapter and apply this information in a clinical context. Concluding comments provide the reader with clinical and research considerations.

10.1 Sleep and ADHD

10.1.1 What Is Sleep and How Does It Work?

Sleep is an essential biological process for the maintenance of a person's physical and mental health, and can be defined as "*an active, repetitive and reversible behaviour serving several different functions, such as repair and growth, learning or memory consolidation, and restorative processes: all these occur throughout the brain and the body*" (Curcio et al., 2006). A collection of neurons in the suprachiasmatic nucleus (SCN) of the hypothalamus are responsible for initiating and regulating the transitions of sleep-wake cycles through a physiological process called the circadian rhythm. A circadian rhythm is a

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biological clock that responds primarily to variations in environmental light levels (Drouyer et al., 2007; Khullar, 2012). When there is a decrease or absence of light, neurons in the SCN activate and trigger the release of melatonin, a hormone from the pineal gland (Drouyer et al., 2007). Once released, melatonin causes an increase in the propensity for sleep (Khullar, 2012).

Sleep is an organized process and has a robust architecture that drives our sleeping patterns. Sleep is divided into two broad types: rapid eye movement (REM) and non-rapid eye movement (NREM). During REM, as the name implies, there are episodic bursts of eye movements associated with dreaming. When in REM sleep, there is a high level of cortical activity, but most of the muscles are paralyzed, so movement is inhibited and one does not act out their dreams. This type of sleep is thought to be critical for learning and memory consolidation. NREM is subdivided into three stages: N1 (transition to sleep), N2 (light or true sleep), and N3 (slow wave or deep sleep). During NREM sleep, body movements are preserved, and cortical activity is low. Restoration of body functions is thought to happen primarily during NREM sleep. The above is referred to as sleep macrostructure, but there is also a deeper level called sleep microstructure that can be examined by analysis of the power spectrum of sleep EEG. For example, the cyclic alternating pattern (CAP) that is found in the NREM stage, and sleep spindles and K-complexes that are only found in the N2 stage are all thought to protect sleep continuity, among other functions.

REM and NREM alternate throughout the night in ultradian cycles of sleep, with each cycle starting with NREM sleep and ending with REM sleep. After each cycle, there is a brief arousal period, which typically does not result in full wakefulness, but rather a quick return to sleep (Kocevska et al., 2021). The timing of ultradian sleep cycles changes across the lifespan, with REM accounting for a greater proportion of sleep for babies and young children than it does for adults. Furthermore, the NREM stage remains relatively consistent across the lifespan, with a decrease in older age (Kocevska et al., 2021). It is not until around 6 years of age that children's sleep stages start to mirror the adult sleep stage proportions of ~25% REM and ~75% NREM (Kocevska et al., 2021). Ultradian sleep cycles in adults are about 90 minutes and occur 4–6 times during sleep, while sleep cycles in children are shorter (e.g., 60 minutes in young children) and are more frequent. Cycles earlier in the sleep period have a greater proportion of NREM, while cycles later in the sleep period (closer to waking) have a greater proportion of REM sleep (Kocevska et al., 2021) (see Fig. 10.1).

Sleep is regulated through the previously described circadian rhythm (sometimes referred to as "Process C") in conjunction with the sleep-wake homeostatic process (referred to as "Process S"), which works on the principle that sleep pressure builds up the longer one is awake (Borbély, 2022). Sleep duration decreases across the lifespan, with guidelines indicating a reduction across developmental stages: 14–17 hours for newborns, 12–15 hours for infants, 11–14 hours for toddlers, 10–13 hours for preschoolers, 9–11 hours for school-aged children, 8–10 hours for adolescents, 7–9 hours for young adults and adults, and 7–8 hours for older adults (National Sleep Foundation, 2020). The timing of sleep also changes across the lifespan. Sleep progresses from polyphasic (short bursts of sleep throughout the day and night) in infants, to multiphasic in toddlers (three sleeping periods a day), to biphasic (two sleeping periods per day) in preschoolers, and to monophasic (one sleeping period per day) in school-aged children. Additionally, wake times remain fairly consistent across the lifespan, but bedtimes slowly become later as children age, with a large shift of approximately 1 hour seen at the time of puberty (Kocevska et al., 2021). Of interest, REM and NREM are related to the two sleep regulation processes: NREM is linked to sleep onset and length of the prior awake period (i.e., the homeostat), whereas REM is linked to the circadian process via body temperature.

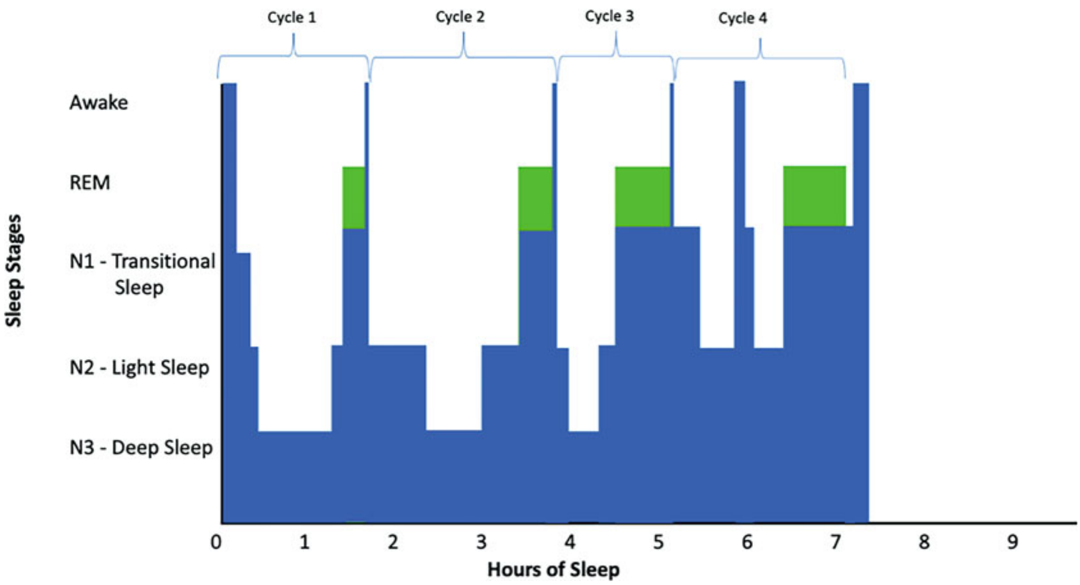

Fig. 10.1 Hypnogram of sleep stages

10.1.2 What Do We Know About Sleep in Individuals with ADHD?

There are mixed findings about whether individuals with ADHD have more sleep problems, what types of sleep problems they have, and the cause of these sleep difficulties. The answers to these questions, in part, depend on the way sleep is measured (see Fig. 10.2). When using subjective measures, such as interviews and parent- or self-report questionnaires, individuals with ADHD across the lifespan are found to have significantly more sleep problems than their healthy, developing peers. However, when using objective measures like actigraphy and polysomnography (PSG), the differences are fewer. In a meta-analysis of studies examining sleep in adults with ADHD, Díaz-Román et al. (2018) found significant differences across many sleep variables based on questionnaires, but only a few differences based on actigraphy and no difference based on PSG variables. In contrast, the result of the meta-analysis conducted by Becker et al. (2019) found that adolescents with ADHD display more sleep problems than controls when assessed by actigraphy and sleep diaries. Differences in sleep included shorter sleep duration, increased daytime sleepiness, and difficulties initiating and maintaining sleep; these differences were evident even after controlling for confounds (Becker et al., 2019).

In our review of reviews (Corkum & Coulombe, 2013), which summarized the results of eight previous published review papers, including three meta-analyses (Cortese et al., 2006, 2009; Sadeh et al., 2006), the only consistent findings were that children with ADHD were reported by parents as having many more sleep problems than their healthy peers, and the only difference found on objective measures was that children with ADHD have increased nocturnal movements. Otherwise, no consistent differences in sleep were found across the three meta-analyses. One reason for these inconsistencies is likely due to the small sample sizes in each of the studies included in the meta-analyses. Another reason is likely due to confounding variables, such as differences in age and sex, diagnostic procedures used, presentations of ADHD,

Fig. 10.2 The objective-subjective continuum of sleep measures

comorbidities with other mental health disorders, and treatment with stimulant medication. Of interest, Baglioni et al. (2016) conducted a meta-analysis of PSG studies (mostly in adults) to determine which mental health disorders were associated with sleep problems, and ADHD was one of only two disorders that was not associated with any sleep alterations.

While there have been no consistent findings between individuals with ADHD and controls related to differences in the macrostructure of sleep (e.g., percentage of time in REM or NREM), more recent research examining the microstructure of sleep has found some interesting results. A recent meta-analysis of 11 studies found evidence of differences in sleep microstructure (e.g., lower CAP rates) in children and adolescents with ADHD compared to their healthy peers (Biancardi et al., 2021). These results suggest an altered cortical maturation for ADHD. In an unpublished study conducted in our research lab, we found ADHD symptoms were correlated with a higher frequency of fast spindles in children (Speth, 2019).

The most researched confounding variable is treatment with stimulant medication. Again, there are conflicting results across studies. A literature review that included seven studies focused on adults (Roth & Zinsenheim, 2009) concluded that while there are sleep disturbances in untreated adults with ADHD, these are not worse (and perhaps even improved) in stimulant-treated adults with ADHD. In contrast, Kidwell et al. (2015) conducted a review that included nine articles about children and adolescents with ADHD. They concluded that stimulant medication increased the time it took to fall asleep, reduced sleep efficiency, and decreased sleep duration (Kidwell et al., 2015). These findings were related to medication dose, length of medication use, how sleep was assessed, and gender (Kidwell et al., 2015). In our review of reviews (Corkum & Coulombe, 2013), we found that in pediatric samples, there was a relatively consistent finding for a negative impact of stimulant medication on sleep, but the severity and chronicity of this impact were unknown. Our recently published study that examined the impact of stimulant medication during a blinded medication trial using objective measures of sleep found, that compared to placebo, the medication condition resulted in increased sleep-onset latency, reduced total sleep duration, and a small increase in the relative percentage of stage N3 (Corkum et al., 2020).

10.1.3 Are There Any Differences in the Circadian Rhythm of Individuals with ADHD?

One interesting and consistent finding in the literature is related to the chronotype of individuals with ADHD. Chronotype is a person's natural predisposition toward a time of day when they feel most alert and energetic (Roenneberg, 2012). It is usually described on a morningness/eveningness continuum (or sometimes referred to as larks and owls). Eveningness has been found to be associated with worse academic performance in children, youth, and young adults (Tonetti et al., 2015), less emotional control and affective stability (Ottoni et al., 2012), and an increased risk of behavior problems (Merikanto et al., 2017). Evening types also have more sleep problems and more night-to-night variability in their sleep (Minz & Pati, 2021). ADHD across the lifespan is associated with more eveningness, including in children (Durmus et al., 2017), young adults (Yilbas et al., 2022), and adults (Snitselaar et al., 2017). This, however, is not without contradictory findings; for example, Tarakçıoğlu et al. (2018) did not find any differences in chronotype between children with ADHD and controls. Most of the research has found that higher eveningness in individuals with ADHD is associated with more sleep difficulties and daytime sleepiness, and this has been found in adults (Durmus et al., 2017), adolescents (Becker et al., 2020), and children (Gruber et al., 2012). Also, individuals with ADHD and high eveningness display more variable sleep schedules (Becker et al., 2017; Langberg et al., 2019), which in turn is associated with poorer sleep. These results call into question the circadian functioning of individuals with ADHD.

Several studies have found differences in circadian functioning in individuals with ADHD compared to healthy controls. In adults, Baird et al. (2012) found behavioral and genetic indicators of impaired circadian functioning, including increased daytime and nighttime activity, phase-delayed cortisol rhythms, shorter locomotor rhythms, and a lack of circadian rhythmicity in the clock genes (Baird et al., 2012). Moreover, Tonetti et al. (2018) found an absence of a post-lunch dip in the circadian activity rhythm in adults with ADHD compared to healthy controls, suggesting lower homeostatic pressure in individuals with ADHD (Tonetti et al., 2018). Differences in melatonin levels between ADHD and healthy controls have also been explored, given the role of melatonin in the timing of the circadian rhythm and sleep. Bumb et al. (2016) found that the volume of the pineal gland (the main producer of melatonin in the brain) was associated with chronotype, and this in turn was associated with the severity of ADHD symptoms (Bumb et al., 2016). Differences in dim-light melatonin onset have also been found in studies with adults with ADHD and phase-delayed sleep (Bijlenga et al., 2013), as well as those with ADHD and sleep-onset insomnia (Van Veen et al., 2010). Similar results have been found in children with ADHD, with Van der Heijden et al. (2005) finding delayed dim-light melatonin onset in children with ADHD and comorbid sleep-onset insomnia. However, Nováková et al. (2011) found no differences in melatonin in children with ADHD without comorbid sleep-onset insomnia compared to healthy controls, although older children with ADHD did show some subtle differences (Nováková et al., 2011).

There is limited research examining the impact of stimulant medication on circadian functioning in people with ADHD, despite consistent findings using animal models that stimulant medications can impact circadian timekeeping (Antle et al., 2012; Baird et al., 2012; Lee et al., 2009). One study in adults with ADHD (Snitselaar et al., 2017) found that treatment with stimulant medication induced delayed circadian rhythmicity. Another study with children undergoing a stimulant medication trial found a reduction in relative circadian amplitude and a phase delay in the timing of the daily rhythm during the medication condition compared to the placebo condition (Ironside et al., 2010).

10.1.4 What Can We Conclude About Sleep in Individuals with ADHD?

It is difficult to make any firm conclusions about sleep in individuals with ADHD. Is it only a perception of sleep difficulties, or are we not able to consistently identify sleep difficulties due to limitations in the measurement of sleep? Or, perhaps the sleep problems are more related to confounding variables, such as treatment with stimulant medication or co-occurring mental health disorders. Another possibility is that differences exist at the microstructure level of sleep, which we are just beginning to explore. The question about the causal directionality between sleep and ADHD is currently unanswered. However, it is likely that there are bi-directional relationships as well as a third factor that may contribute to both ADHD and sleep problems. For example, Saletin et al. (2018) conducted a meta-analysis of 134 articles to examine fMRI results that compared individuals with ADHD to those who were sleep deprived. These researchers found that both groups displayed hypoactivation in the executive function regions of the brain. Interestingly, the sleep-deprived group, but not the ADHD group, displayed hyper-activation of the thalamic area, which the authors interpreted as a potential compensatory response not found in the ADHD group. Similar results were found by Shen et al. (2020), who, after examining data from large longitudinal brain imaging datasets, concluded that ADHD and sleep disorders have common neural correlates, with structural changes in the ventral attention system and frontostriatal circuitry. Genetic data also supports the shared third variable hypothesis (Carpena et al., 2021; Wang et al., 2020).

What is clear from this review of literature examining the relationship between ADHD and sleep is that we need large-scale networks of researchers, like the one described by Tahmasian et al. (2021), that can conduct studies with large sample sizes so that the limitations of the literature can be addressed. Until we have better data to answer the question about the relationship between ADHD and sleep, we will have to make educated guesses based on the current body of literature. It would seem most likely that the main difference in sleep in individuals with ADHD across all ages is disruption in the circadian system. This is in line with the findings by Bijlenga et al. (2019), based on an extensive literature review, that individuals with ADHD experience a delayed circadian rhythm. The exact nature of this disruption and the reasons for this are unknown, but this disruption would make individuals with ADHD vulnerable to the sleep disorders that we know are prevalent in this population, including insomnia and delayed sleep phases. There is also some consistency in the evidence for dysregulated motor movements during the day and night, and differences in sleep microstructure.

10.1.5 What Is the Impact of Poor Sleep?

There is a large body of research that supports the notion that poor sleep negatively impacts the individual, their families, and society. At an individual level, people with poor sleep experience increased levels of stress, more social and emotional problems, increased behavioral challenges, and potentially even differences in brain function and structure (Dutil et al., 2018; Gardani et al., 2022; Lucas et al., 2019; Mulraney et al., 2016; Womack et al., 2013). At a family level, Coles et al. (2022) conducted a systematic review of 29 studies and found evidence that a child's sleep problems were associated with poorer health and well-being in mothers and fathers, as well as impacting the quality of the relationship between the parents, and between the parent and child. Wells and Vaughn (2012) described the impacts on society, which range from major disasters, productivity issues, stress, drowsy driving, substance use, mortality and morbidity, overall health and well-being, and impacts on the healthcare system as well as economic costs. This research, which is primarily correlational in nature, is further supported by the results of experimentally manipulated sleep studies, which provide evidence for the causal impacts of sleep restriction. A number of studies have found sleep restriction resulting in poorer affective functioning (Tomaso et al., 2021), poorer attention (Lundahl et al., 2015), increased stress and aggression (Demichelis et al., 2022), poorer emotional and cognitive functioning (Vriend et al., 2013), and poorer school performance and cognitive outcomes (Hayes & Bainton, 2020).

When comparing individuals with ADHD with and without sleep problems, more negative outcomes have been found for those with sleep problems for both adults and children with ADHD (Davidson et al., 2018; Lunsford-Avery et al., 2016). Adults with ADHD and comorbid sleep problems were found to have more severe ADHD symptoms (Vogel et al., 2017), and to be at increased risk for poor mental health and loss of productivity (van Andel et al., 2022). Young adults with ADHD and sleep problems were found to experience more academic problems, increased functional impairment and subjective cognitive concerns, and increased rates of mental health concerns (Gloger & Suhr, 2020). Mothers of children with ADHD and comorbid sleep problems had more mental health problems (Martin et al., 2021). Of interest, disrupted sleep in infancy was found to increase the odds of a later ADHD diagnosis in a large meta-analysis study (Shephard et al., 2022), and a history of sleep problems was associated with the severity of ADHD symptoms in adults (Vogel et al., 2017). Dimakos et al. (2021) concluded that "sleep problems precede, predict, and contribute to the manifestation of internalizing and externalizing behavior problems in children and adolescents with ADHD." The small body of research on experimental sleep manipulation studies confirms many of the correlational findings reviewed above. For example, Becker et al. (2020) demonstrated a causal relationship between short sleep and affect/mood disturbances in adolescents with ADHD. In research focused on children, Gruber et al. (2011) demonstrated that sleep restriction in children with ADHD resulted in increased attentional impairment, while Davidson et al. (2021) demonstrated a similar increase in both attentional problems and emotional dysregulation. Interestingly, sleep problems have also been found to predict treatment effectiveness and side effects in children with ADHD (Davidson et al., 2021).

Regardless of the cause of sleep disruptions in individuals with ADHD, we know that age-appropriate sleep quantity and quality are critical for overall mental and physical health. There is a growing change in focus from a sleep medicine perspective (i.e., focus on sleep disorders) to a sleep health perspective (focused on the positive role of sleep for overall health) (Buysse, 2014). The impact of insufficient sleep from both a sleep medicine (i.e., sleep disorders) and sleep health perspective has clearly identified the substantial and broad impacts on daytime functioning, as well as health and well-being. It is clear that sleep problems in individuals with ADHD at any age disrupt daily life and impact quality of life, and as such, they need to be assessed and treated to optimize their health and well-being.

10.2 Assessment of Sleep

An accurate assessment of sleep is critical to establishing a sleep disorder diagnosis, which in turn guides treatment planning. Sleep measures are commonly described along a continuum from objective to subjective (Markovich et al., 2015). Each assessment tool has strengths and weaknesses in the context of assessing specific sleep disorders. Typically, in a clinical assessment, it is best to use multiple measures to assess the full presentation of the sleep difficulty. In research, the selection of the sleep measure(s) is often driven by practicalities. For example, in studies with large sample sizes, subjective measures are frequently used, while studies with smaller sample sizes allow for objective measurement of sleep. The need for multiple measures is underscored by the fact that the correlation between measures is low, especially in various medical, sleep, and psychiatric disordered populations (Rezaie et al., 2018). As well, it can be difficult to accurately report sleep quality/quantity, and sleep misperception is a well-known phenomenon in individuals with sleep disorders (Schinkelshoek et al., 2020).

10.2.1 What Are the Most Common Assessment Tools?

Below, we describe seven commonly used assessment tools (or categories of assessment tools), starting with the most objective and ending with the most subjective (Rigney et al., 2021). Along with the description, we include the type of diagnoses for which the measure is best suited, as well as the strengths and weaknesses of the measure (see Table 10.1).

10.2.2 What Is the Suggested Approach to the Assessment of Sleep?

Described below is the stepped approach to sleep assessment, which is similar when working with individuals from across the lifespan (see Fig. 10.3). In this description, we also note some of the most commonly used and psychometrically valid sleep measurement tools. It is important to note that many of the negative outcomes of insufficient sleep are found regardless of whether the individual meets the criteria for a sleep disorder. Moreover, the sleep complaint being based only on subjective reports does not mitigate the impact it can have on daytime functioning. This further underscores the need for sleep assessment and intervention of sleep difficulties as well as sleep disorders. Unfortunately, this rarely happens due to a range of factors, including limited education for healthcare providers about the assessment and treatment of sleep problems, limited access to resources, and few referral sources for treatment, as well as limited time to incorporate this into current assessment practices (Schreck, 2010). It has been argued that increased integrated primary care is needed, as this would allow for healthy behaviors, such as sleep, to be addressed as part of routine care (Funderburk et al., 2018; Golden et al., 2022). While some knowledge and skills are required to conduct a clinical assessment focused on sleep problems, for the most part, this is well within the scope of practice for most frontline health professionals. Referral to a sleep specialist is often only needed when objective measures of sleep are required to confirm a sleep disorder, such as a sleep-related breathing disorder.

10.2.2.1 Step 1: Screening

Given the high rates of sleep problems and sleep disorders across the lifespan, as well as their ubiquitous impact in daily life, it is recommended that individuals are screened for sleep problems as part of usual care, as well as in the context of assessment for other mental and physical health problems. Questionnaires/rating scales are designed to be used as screening tools, not for diagnosing specific sleep disorders. It is recommended to start with a broad-band questionnaire that assesses for a range of sleep problems. The information collected can help identify what questions need to be further explored for their client. If appropriate, the clinician can follow up with a narrow-band questionnaire that focuses on one or a group of related sleep disorders.

An extensive review of existing questionnaires for the pediatric population was recently published by Sen and Spruyt (2020). This is an update of their previous review (Spruyt & Gozal, 2011). In the 2020 review, the researchers identified and evaluated 70 parent-report questionnaires used in the assessment of sleep problems in children and youth ages 6–18 years. Despite the large number of tools, including both broad- and narrow-band measures (about 50/50), many had not been evaluated for their psychometric properties, and only 18 measures had some normative data that would allow the clinician to compare their client's scores to their peers. They concluded their review by noting that there is a need for more psychometrically validated tools and for tools that assess aspects beyond sleep disorders (e.g., chronotype) for adolescents,

Table 10.1 Sleep assessment tools

Description
Polysomnography (*PSG*) is considered the "gold standard" measure of sleep. It is an overnight test that monitors multiple body physiological parameters, including electrical brain activity (EEG), blood oxygen level, heart rate, breathing patterns, and eye and leg movements. It is most often conducted in a sleep laboratory. PSG is primarily used to diagnose sleep disorders with physiological etiologies, such as sleep-related breathing disorders and sleep movement disorders. It should not be routinely used to diagnose insomnia. PSG allows for the most detailed sleep data to be collected, including EEG data that can be used to determine sleep stages (e.g., amount and timing of REM and NREM). Given that it is collected in a highly controlled and novel environment, the ecological validity of the data can be impacted. A "first-night" effect is common (i.e., individuals sleep differently than usual). Further, PSG is costly and can be seen as intrusive by some (e.g., multiple electrodes being observed during sleep).
Multiple Sleep Latency Tests (*MSLT*) measure daytime sleepiness through a series of nap opportunities (usually five) scheduled in 2-hour intervals throughout the daytime. Each nap opportunity lasts for 20 minutes. Like PSG, EEG is monitored so that sleep staging can be determined. It is most often used to diagnose narcolepsy and other types of hypersomnia. Like PSG, the ecological validity is low, but the precision of the data is high.
Infrared videography consists of video and audio recording using infrared camera technology so that movements or behaviors can be recorded and later reviewed. This measurement tool can be used to assess abnormal behaviors during sleep, such as parasomnias and REM behavior disorders. It can also be used in the differential diagnosis of sleep disorders and epilepsy. Infrared video is often used in conjunction with PSG, which increases the interpretability of PSG findings. However, given that this is a novel sleep environment, the ecological validity is low. With decreased costs of this technology, it is now possible to use it in the home environment, which can increase ecological validity.
Actigraphy uses a watch-like device (an actigraph) to collect information about body movements throughout the night (and day, if needed). Actigraphs are often equipped with light sensors and a button that allows one to mark events, such as bedtime. The actigraph is generally worn on the non-dominant wrist, but in younger children, it may be worn on the ankle. Actigraphy can provide helpful information in a clinical assessment for circadian rhythm disorders. Actigraphs are less expensive and less intrusive than PSG, but they do not provide as much detailed information as PSG does. For example, actigraphy does not collect information about sleep stages or symptoms related to sleep-disordered breathing. While the ecological validity is high (assesses sleep in the natural environment over many days), it provides only an estimate of sleep parameters and may not be as accurate in some populations that have movement disorders.
Sleep Diaries include a physical or digital series of questions that ask an individual or a proxy for the individual (i.e., parents reporting on their child's sleep) to provide an estimate of sleep-related variables (e.g., sleep and wake times, night wakings, daytime naps, and other variables of interest). Sleep diaries are meant to be recorded in real-time and are typically completed daily for 1–2 weeks. Sleep diaries are inexpensive to complete but can be onerous for the person completing them over several nights. The ecological validity is high, but there may be some response biases, although these are thought to be mitigated by collecting the information in real time rather than through reflection. Additionally, given that a lot of data are typically collected, it can be difficult for the clinician to interpret it. Sleep logs (or somnologs), which are a visual form of sleep diary, can help mitigate some of these problems, but less information is collected.
Sleep Questionnaires can be either self- or proxy-reported. There are a wide range of published sleep questionnaires to choose from. These include broad-band sleep questionnaires, which cover various sleep disorder symptoms, and narrow-band sleep questionnaires, which focus on one sleep disorder. Questionnaires are screening tools, not diagnostic tools. The ecological validity is very high, but questionnaire data does not have a high correlation with objective data, potentially due to biases in self- and proxy-report.
Interviews help to guide the clinician's assessment and treatment planning. The interview should explore issues related to both physical and mental health and aim to uncover specific sleep issues. Collecting historical information about the sleep problem is one of the most important parts of a clinical interview. Interviews are a great way to collect important information to direct the assessment process, but they do not typically result in diagnosing a sleep disorder. Like other subjective measures, the ecological validity is high, but the diagnostic utility is low.

young adults, and specific populations (e.g., developmental disabilities). Similar conclusions were reached in reviews of sleep questionnaires for adolescents (Ji & Liu, 2016) and adults (Klingman et al., 2017; Huhn et al., 2022). A book titled *STOP, THAT and One Hundred Other Sleep Scales* (Shahid et al., 2012) provides information and psychometrics for over 100 scales, both broad- and narrow-band, and for across the lifespan (Shahid et al., 2012).

Some of the most widely used and psychometrically sound broad-band questionnaires in the

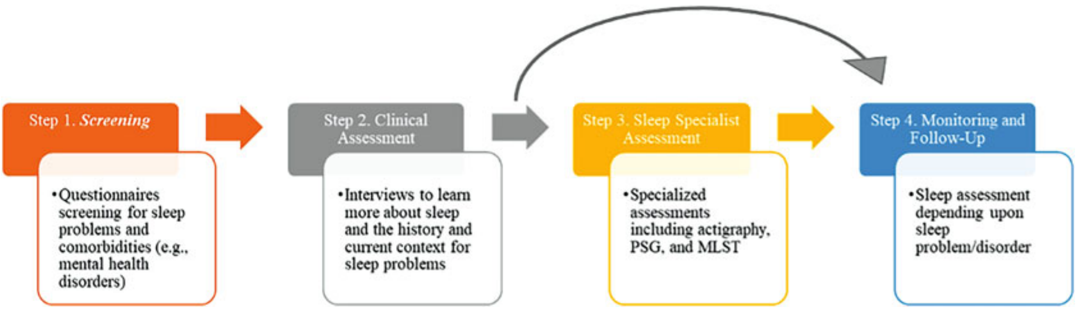

Fig. 10.3 Stepped approach to sleep assessment

pediatric population include the Child Sleep Habits Questionnaire (Owens et al., 2000) and the Pediatric Sleep Questionnaire (Chervin et al., 1997). In the adult population, widely used broad-band sleep questionnaires include the Pittsburgh Sleep Quality Index (Backhaus et al., 2002) and the Epworth Sleepiness Scale (Heaton & Anderson, 2007). Narrow-band questionnaires, which focus on one sleep problem area, are also widely used clinically and in research. For example, if there were concerns about insomnia, one could use the *Insomnia Severity Index* for adults (Morin et al., 2011), and the *Pediatric Insomnia Index* for children (Byars et al., 2016).

Based on a National Institutes of Health Roadmap initiative, a set of over 300 measures (PROMIS; Patient Reported Outcomes Information System; Cella et al., 2007) have been developed to assess physical, mental, and social health in adults and children. These measures are well-validated, are highly accessible and free to use, exist in multiple formats (print and digital), are translated into many languages, and can be used in research and clinical practice. There are sleep assessment measures for adults and children (both self-report and parent-proxy report) that include long and short forms for symptom-focused questionnaires, as well as a sleep-related impairment questionnaire. Sleep items are also included in the general assessment measures ("PROMIS Profile"). The psychometric properties of these measures have been well-researched for the pediatric scales (Bevans et al., 2019; Forrest et al., 2018; Lai et al., 2022) and adult scales (Buysse et al., 2010). These measures have also been validated for use in some special populations such as children with chronic illnesses and neurodevelopmental disorders (Meltzer et al., 2020).

10.2.2.2 Step 2: Clinical Assessment

It is best to start the clinical assessment with an interview to better understand the sleep concerns and symptoms, as well as the history of the concern. Reviewing screening questionnaire results with the client/parent of the client can be helpful to further understand the sleep problem. The clinician can also use existing interview guides, such as the BEARS questionnaire (Owens & Dalzell, 2005). The BEARS is a short (five-item) tool that assesses each letter in the acronym – *B*edtime issues, *E*xcessive daytime sleepiness, night *A*wakenings, *R*egularity and duration of sleep, and *S*noring. It can be used in pediatric and adult populations by a clinician to screen for sleep difficulties, and it can collect important information about sleep complaints (Weiss et al., 2019).

After the clinical interview (or sometimes before the clinical interview), it is often very helpful to have the client/parent of the client to collect sleep diaries/logs. To gain a representative sample of sleep-wake behavior, it is important to collect a minimum of 2 weeks of sleep diaries. Sleep diaries can either be visual, collecting only basic information about sleep and wake times and night awakenings (these are often called sleep logs), or they can be more extensive and collect comprehensive information about sleep-wake behaviors and information that may help to understand the sleep problems (e.g., what an individual is drinking or eating before bed, and physical activity during the day).

10.2.2.3 Step 3 (If Required): Sleep Specialist Assessment

If further information is required that is not within the scope of practice for the clinician, then a referral to a sleep specialist may be required. For example, if a PSG, MLST, or actigraphy assessment is required, then a referral would need to be made. Unfortunately, this can be a challenge given that there is a disparity in access to sleep specialists in some underserviced geographical areas (Corkum et al., 2019b).

10.2.2.4 Step 4: Monitoring and Follow-Up

It is critical that the assessment of sleep problems is ongoing and include monitoring and follow-up. If any interventions are put in place, it is imperative to monitor them to ensure these treatments are effective. Using some of the questionnaires noted above can be useful for monitoring the impact of an intervention. Screening tools can also be used in ongoing follow-up, which is critical given the changing nature of sleep across the lifespan.

10.2.3 What Considerations Need to Be Made for Individuals with ADHD?

When conducting a sleep assessment with an individual with ADHD, the same stepped process as outlined above is followed; however, there are some special considerations. Given the frequent reports of sleep problems in individuals with ADHD, as well as the clear bi-directional impacts between inattention and insufficient sleep, it is advised that a sleep screening assessment be conducted along with the initial ADHD assessment (Corkum et al., 2011; Cortese et al., 2013). Assessing for both ADHD and sleep problems is critical to determining if there is a differential diagnosis (given that sleep disorders and/or disrupted sleep can mimic ADHD symptoms), as well as assessing for potential comorbidity, which could exacerbate ADHD symptoms. It is also recommended that there be a baseline sleep assessment prior to starting stimulant medication. If the individual is already on stimulant medication, then the impact this has on their sleep also needs to be considered.

There are some considerations needed in terms of the measurement of sleep in individuals with ADHD. As noted previously, in both children and adults with ADHD, subjective measures identify many sleep problems, while objective measures identify few, if any. In our research examining the concordance between measures, we found lower concordance between subjective and objective measures in children with ADHD, particularly those who are not being treated with stimulant medication and compared to their healthy peers. This was interpreted to be the result of increased nocturnal movements, which have been shown in previous studies (Markovich et al., 2015; Waldon et al., 2016). Also, given the potential that individuals with ADHD have more night-to-night variations in their sleep, there may need to be a longer recording period for sleep diaries and actigraphy to capture the full range of sleep-wake behavior. Furthermore, given the demanding nature of recording sleep diaries, consideration should be given to use a sleep log rather than a sleep diary to reduce the time and effort required to complete them, especially given that additional nights of recording are recommended (Weiss et al., 2019). Finally, it is important to consider the impact that comorbid mental health disorders may have on sleep. Individuals with ADHD have high rates of comorbidity, many of which are also associated with sleep problems/disorders. For example, comorbid anxiety is especially high in adults with ADHD, and anxiety has been related to sleep problems such as shorter sleep quantity and quality (Cox & Olatunji, 2020).

10.3 Sleep Disorders and Treatment

There are many causes of sleep problems (e.g., lifestyle factors, stress, and anxiety), with intrinsic sleep disorders being the cause for approximately 30% of people across all developmental stages. The International Classification of Sleep Disorders, Third Edition (Sateia, 2014), and the Diagnostic and Statistical Manual, Fifth Edition (Text Revision) (American Psychiatric Association, 2022) both provide the diagnostic criteria for sleep disorders; however, most sleep specialists prefer to use the ICSD-3 due to the greater depth of information. The ICSD-3 includes ten different sleep disorders/sleep disorder groupings (i.e., insomnia disorder, hypersomnolence disorder, narcolepsy, breathing-related sleep disorders, circadian rhythm sleep-wake disorders, non–rapid eye movement (NREM) sleep arousal disorders, nightmare disorder, rapid eye movement (REM) sleep behavior disorder, restless legs syndrome (RLS), and substance/medication-induced sleep disorder). It is helpful to conceptualize sleep disorders using a biopsychosocial model, which considers the biological, psychological, and social factors (Engel, 1977). When planning for treatment, it is helpful to use the 4P framework to identify predisposing, precipitating, perpetuating, and protective factors (Barker, 1988).

While we still do not know the exact relationship between ADHD and sleep, it is clear that ADHD is a 24-hour disorder that impacts not only daytime functioning but also disrupts nighttime functioning. It has been estimated that approximately 30% of children and 70% of adults with ADHD reach the diagnostic criteria for a sleep disorder (Yoon et al., 2012). The evidence is strongest for the following three mechanisms for sleep disruption in individuals with ADHD: (1) dysregulation of motor movements, which are seen as hyperactivity during the day and restless sleep during the night; (2) impairments in the circadian clock, so that falling asleep at appropriate times is challenging; and (3) potential differences in the microstructure of sleep that can cause individuals with ADHD to be vulnerable to sleep disruptions. Given these problems, it is not surprising that the most common sleep disorders in individuals with ADHD are insomnia, delayed sleep phase, and restless legs/periodic limb movement disorder (PLMD). We will focus on these three sleep disorders, as well as summarize evidence for other sleep disorders in ADHD. We will describe each sleep disorder using the diagnostic criteria from the ICSD-3, review what is known about this disorder in individuals with ADHD, discuss the best clinical treatment and evidence for the treatment, and then provide considerations for individuals with ADHD.

10.3.1 Insomnia

10.3.1.1 What Is Insomnia Disorder, Its Prevalence, Etiology, and Impacts?

Insomnia disorder is defined in the ICSD-3 as frequent (3 or more nights a week) and chronic (3 or more months) difficulties with initiating and/or maintaining sleep despite adequate opportunity and conditions for sleep that negatively impact daytime functioning. While there are no specific subtypes of insomnia included in the ICSD-3, there are different developmental presentations, with children displaying difficulties with sleep-onset associations (e.g., having to have a parent with them to fall asleep) and limit-setting (e.g., bedtime resistance), adolescents displaying problems with healthy sleep practices (e.g., viewing screens in bed, inconsistent sleep schedules between weekdays and weekends), and adults displaying the symptoms of arousal and worry about sleep. Adolescence is a peak time for the onset of insomnia. The etiology of insomnia is multifaceted. For example, heritability estimates for insomnia are ~40% (Barclay et al., 2021), and there may be an epigenetic mechanism whereby stressful experiences in early life may increase sensitivity to stress, and as such, the impact of stress on sleep (Palagini et al., 2014). It is also well known that social-cultural, demographic (e.g., socioeconomic factors), sleep environment, and sleep practices can contribute to the development of insomnia disorder (Bos & Macedo, 2019; Mai & Buysse, 2008).

In the general population, insomnia is the most common sleep disorder across all ages and is also the most common sleep disorder in individuals with ADHD. It is estimated that approximately 10–15% of adults in the general population meet diagnostic criteria for insomnia disorder (Kraus & Rabin, 2012). While there are no prevalence data specifically for insomnia in individuals with ADHD, Brevik et al., 2017 found that the rates of insomnia symptoms in adults with ADHD were more than twice as high compared to adults without ADHD, and that those with a combined presentation of ADHD had higher rates of insomnia disorder than those with an inattentive presentation of ADHD. A study on adolescents found that almost 30% of those with ADHD had insomnia disorder (Hysing et al., 2022). For children, a diagnosis of insomnia disorder is not as common, but symptoms of insomnia are very prevalent, with ~30% of children displaying these symptoms, and up to 70% of children with ADHD displaying these symptoms (Sung et al., 2008). Insomnia has been identified as a public health crisis given its high prevalence and significant impacts; it is estimated to cost billions of dollars annually in direct and indirect costs (Chaput, 2019; Kraus & Rabin, 2012). Comorbidity of insomnia with ADHD increases negative outcomes, including increased mental health symptoms and lower productivity (van Andel et al., 2022).

10.3.1.2 How Is Insomnia Disorder Assessed and Treated?

Assessment of insomnia usually involves a clinical assessment, including interviews and sleep diaries. PSG is not indicated unless needed to evaluate for other sleep disorders, such as sleep breathing disorders. The first-line treatment for insomnia in adults is cognitive behavioral therapy for insomnia (CBT-I). CBT-I is a multicomponent intervention that includes multiple behavioral and cognitive strategies. The cognitive strategies target maladaptive thoughts and beliefs about sleep and sleep problems (e.g., it is abnormal to take time to fall asleep), while the behavioral strategies help prepare one's body to sleep (e.g., relaxation training, sleep restriction to increase one's homeostatic sleep drive), and build the conditions under which sleep is more likely (e.g., developing healthy sleep habits, such as not being exposed to bright light before bedtime, scheduling sleep to strengthen the circadian rhythm, and stimulus control, such as associating the bed with sleep). This intervention is traditionally delivered individually during face-to-face sessions. There is a very large evidence base that establishes CBT-I as an effective treatment. For example, a recent meta-analysis of 87 RCTs found that CBT-I was effective based on many sleep variables (e.g., reducing the insomnia severity index, decreasing the time for sleep onset, reducing the number of awakenings at night, increasing sleep quality, as well as having a smaller effect on increasing total sleep time), and this effectiveness was found across many potential covariates, including age, medication usage, and comorbidity (van Straten et al., 2018). These authors concluded that face-to-face interventions lasting at least four sessions were most effective (van Straten et al., 2018).

Positive outcomes for daytime functioning have also been found with CBT-I treatment. For example, meta-analyses have found improvements in quality of life, depressive and anxiety symptoms, and social functioning (Alimoradi et al., 2022; Benz et al., 2020). Recently, these results have been extended to individuals with comorbid mental and physical health disorders. A meta-analysis including 22 studies of adults with mental health disorders (not specific to ADHD) found moderate-to-large effects of CBT-I on insomnia severity and a reduction in mental health symptoms, leading the authors to conclude that CBT-I should be first-line treatment for insomnia in individuals with mental health disorders (Hertenstein et al., 2022). Moreover, a meta-analysis of 23 studies concluded that CBT-I is more effective than pharmacotherapy (Zhang et al., 2022). While there is some evidence for the efficacy of pharmacological treatment in adults, there are also concerns about side effects. Given this and the superior effectiveness of CBT-I, it is recommended that CBT-I be the first-line treatment for insomnia (Riemann et al., 2017). If medication is indicated, it needs to be tailored to the needs of the individual (e.g., consideration of other medications and comorbidities), and should only be used intermittently and for the short term (Bragg et al., 2019).

Despite the large and robust findings for the effectiveness of CBT-I, its delivery to all who need treatment for insomnia disorder places a burden on the healthcare system, and as such, CBT-I is often not accessible to individuals in need (Roach et al., 2021). This has resulted in a search for accessible and cost-effective methods to deliver CBT-I. Recent meta-analyses have found that brief behavioral treatment for insomnia (Kwon et al., 2022) and group CBT-I (Navarro-Bravo et al., 2015) were effective in improving insomnia symptoms. As well, two recent network meta-analyses that compared different CBT-I delivery formats (e.g., individual, group) and digital formats (e.g., telephone, web-based, apps) found that all formats were effective compared to control conditions (Gao et al., 2022). Individual, group, and digitally assisted CBT-I formats were found to be the most effective (Gao et al., 2022), and of the digital formats, having an intervention with a therapist (live or virtual) was found to be the most effective (Hasan et al., 2022).

While there is a large body of research about the treatment of insomnia disorder in adults, much less is known about the treatment of insomnia in children and adolescents. However, existing research holds promise for this treatment in adolescents. In a sample of over 100 adolescents, de Bruin et al. (2018) compared group CBT-I and internet CBT-I to a waitlist condition and found both active treatments resulted in improved sleep and psychopathology symptoms in the short and long term. In children, a behavioral approach implemented by parents/caregivers to treating insomnia/insomnia symptoms is more common (Rigney et al., 2021). This most often starts with psychoeducation (i.e., teaching parents about sleep and addressing any misconceptions/myths) and the implementation of healthy sleep practices (previously called sleep hygiene). While this is often an effective first step of intervention for children, research indicates that the implementation of only healthy sleep practices for adults is less effective than CBT-I (Chung et al., 2018). If psychoeducation and healthy sleep practices are not sufficient to treat child sleep problems, then the next step is to implement behavioral strategies (see Table 10.2 for a list of behavioral strategies). There are no medication treatments approved for the treatment of insomnia in children (Bruni et al., 2018; McDonagh et al., 2019), and there are a few digital interventions to treat insomnia in adolescents/children. A recent review by McLay et al. (2020) identified five studies of telehealth interventions, all of which found positive outcomes in terms of improving children's sleep.

10.3.1.3 What About the Treatment of Insomnia in Individuals with ADHD?

Like the general guidelines for treating insomnia disorder/insomnia symptoms (Riemann et al., 2017), it is recommended that individuals with ADHD are also provided with CBT-I/behavioral interventions as a first-line treatment (Cortese et al., 2013; Hertenstein et al., 2022). Unfortunately, this is often not the case, with many individuals with ADHD being prescribed medications for sleep difficulties, regardless of age (Angriman & Cortese, 2022). For individuals with ADHD who are being treated with stimulant medication and who experience sleep problems, their medication, dose, and timing of the dose should also be reviewed and potentially adjusted so it does not interfere with sleep (Angriman & Cortese, 2022).

There is limited research on CBT-I for adults with ADHD. A recent pilot study of CBT-I adjusted for ADHD with 19 participants concluded that the program led to promising results (Jernelöv et al., 2019). Similarly, a small pilot study of 10 adults with ADHD and autism spectrum disorder (ASD) found that a behavioral sleep intervention for insomnia (which included sleep scheduling as the core component) was effective at improving sleep, as well as some core ASD symptoms (e.g., attention switching).

Our team has been developing and evaluating a web-based multi-component sleep intervention (*Better Nights, Better Days*) for both typically developing children and children with neurodevelopmental disorders, including ADHD. This intervention holds promise for

Table 10.2 Behavioral strategies used to treat sleep problems

Intervention	Description
Unmodified extinction	Also known as the "Cry it Out" method. The infant/toddler is placed into bed while awake and is left alone until they are asleep. If the infant has night-wakings, they are ignored. The goal is for infants/toddlers to learn how to self-soothe once they realize that night-time crying does not result in parental attention.
Modified extinction	The infant/toddler is placed into the bed when they are sleepy or drowsy. The parent remains in the room during the extinction period, acting as a reassurance for the infant/toddler, but providing little interaction.
Graduated extinction	This involves the parent ignoring negative behaviors (e.g., crying) for a period of time before checking in on the infant/toddler. The parent gradually increases the amount of time between crying and the parental response. Parents provide reassurance through their presence for a short period of time with minimal interaction.
Bedtime Fading	Operates by gradually delaying bedtime closer to the child's target bedtime. Bedtimes can be gradually moved earlier or later. The goal of bedtime fading is for the child to develop a positive association between being in bed and falling asleep rapidly.
Stimulus control	Involves making the bedroom/bed a discriminant stimulus for sleep for children by only using the bedroom/bed for sleep (not play, time-outs, etc.).
Sleep scheduling	Involves scheduling regular and appropriate sleep and wake times that allow for adequate sleeping opportunities. Includes changing when you go to bed, changing when you get out of bed, changing how much time you spend in bed, and/or limiting naps.
Sleep restriction	Designed to remove middle-of-the-night awakenings, restrict time in bed to build sleep pressure, and gradually lengthen time in bed as sleep efficiency improves. Has been shown to be contraindicated in youth with parasomnias, seizure disorders, OSA, and mania.
Cognitive strategies	These strategies are used to improve non-productive beliefs about sleep, such as the belief that a child cannot change their sleep difficulty. Coping strategies are also included, such as relaxation skills like abdominal breathing.
Relaxation training	Teaching diaphragmatic (abdominal) breathing and progressive muscle relaxation to reduce arousal, anxiety, and stress. This strategy needs to be practiced regularly before introducing it at bedtime.
Reward programs	Involves reinforcing healthy sleep practices, having appropriate bedtimes, short sleep latency, etc.

being an acceptable and effective intervention to improve sleep and daytime functioning for children with ADHD (Corkum et al., 2016; Rigney et al., 2018; Tan-MacNeill et al., 2020). Hiscock and colleagues have been developing and evaluating a brief behavioral intervention for sleep problems (including behavioral interventions and healthy sleep habits) in children with ADHD, which is delivered by frontline healthcare providers. This intervention was found to be effective in an RCT (Hiscock et al., 2015) as well as when delivered by frontline healthcare providers in community settings (Hiscock et al., 2019).

The above interventions used the same strategies as what is used with non-ADHD clients. However, Jernelöv et al. (2019) modified the delivery to help the client implement the intervention strategies (e.g., using an alarm/calendar to set reminders) and make the information more accessible (e.g., shorter sessions, presenting content in shorter bursts). Corkum included some ADHD-specific content (e.g., information about the link between sleep and ADHD) and tips on how to implement the strategies when the child has ADHD (e.g., keeping instructions short and varying rewards; Corkum et al., 2019a).

10.3.2 Delayed Sleep-Wake Phase Disorder (DSWPD)

10.3.2.1 What Is DSWPD, Its Prevalence, Etiology, and Impacts?

Circadian sleep/wake disorders are conditions where the individual's internal clock is misaligned with societal norms. Delayed sleep-wake phase disorder (DSWPD) is the most common circadian sleep-wake disorder. It is defined as having sleep onset occur 2–6 hours later than what is desired and later than socially accepted sleep times, but otherwise, it is normal sleep. Additionally, having symptoms of excessive sleepiness and/or insomnia and having clinically significant distress or impairment are part of the definition of DSWPD (Sateia, 2014). The disorder itself does not result in daytime sleepiness or other daytime impairments, unless there is a misalignment of the individual's schedule relative to circadian timing. This results in sleep debt by restricting the hours of sleep (Miano, 2017). For example, if an individual with DSWPD can delay work or school start times so that they are able to get age-appropriate sleep quantity and quality, then there is no impairment from this disorder. However, these accommodations are often not feasible, and as such, many individuals with DSWPD experience daytime impairments that are associated with poor sleep. Adolescence is the developmental stage that has the greatest risk for developing DSWPD given the biological shift to a later bedtime and the psychosocial factors delaying bedtime (Gradisar et al., 2011).

The prevalence of this disorder is thought to range from 1% to 10%, with different prevalence rates across the lifespan. In adolescents, 3–7% meet diagnostic criteria, whereas in middle-aged adults, only 1% meet diagnostic criteria (Micic et al., 2016). Children are rarely diagnosed with DSWPD, although they may have subthreshold symptoms. The prevalence is much higher in individuals with mental health disorders. It has been estimated that ~25% of children and adults with ADHD have DSWPD (Bijlenga et al., 2019). It is also important to note that DSWPD and insomnia are highly comorbid, with ~60% of adolescents with DSWPD also meeting criteria for insomnia disorder (Micic et al., 2016). Difficulties falling asleep at conventional (and needed) times could set the stage for the development of insomnia.

While the exact etiology of DSWPD is uncertain, it is thought to be a delay in the timing of circadian rhythms, which results in a reduced drive to sleep at conventional bedtimes. There is consistent evidence that individuals with DSWPD have delayed timing of changes in core body temperature and dim-light melatonin onset (DLMO), which precede sleep (Wiggs, 2019). It is believed that there is a strong genetic loading for delayed phase sleep disorder (DPSD) that predisposes individuals to develop this disorder. A longer circadian period is likely the precipitating factor, and reduced exposure or sensitivity to morning light and increased exposure or sensitivity to light later in the evening may perpetuate this delay. There is also some emerging evidence that individuals with DSWPD may have differences in their homeostatic pressure accumulation during the day and dissipation while sleeping (Micic et al., 2016). Evidence also points to some behavioral contributions, such as inappropriate light exposure, participating in activities late at night, and consuming stimulants (e.g., coffee, stimulant medications) in the evening (Wiggs, 2019).

10.3.2.2 How Is DSWPD Assessed and Treated?

There are several questionnaires that can be used to screen for DSWPD. Questionnaires that assess daytime sleepiness (e.g., Epworth Sleepiness Scale) and those that assess chronotype (e.g., Morningness-Eveningness Questionnaire-Self-Assessment Version; (Horne & Östberg, 1976) can be helpful, along with a general sleep questionnaire, to determine if there are other sleep problems/disorders that need to be considered. A diagnosis of DSWPD is usually based on a clinical interview and monitoring of sleep (Gradisar et al., 2011). The clinical interview focuses on factors such as the perceived reasons for difficulties sleeping, the historical course of sleep problems, and the impact of symptoms. Sleep is usually monitored for at least 1 week of data collection in the home setting via a sleep diary and/or actigraphy. It is helpful to include days when the individual is allowed to sleep and wake at their natural circadian rhythm, compared to days when the individual has prescribed bed and wake times that are consistent with societal conventions (e.g., in bed to fall asleep at 11 pm and waking at 7 am). Collecting this information can help distinguish the symptoms of DSWPD from those of insomnia. While it is possible to assess DLMO via repeated salivary samples, this is not often used in clinical assessment for practical reasons (e.g., lack of availability in clinical laboratories). Typically, a PSG assessment is not needed unless there is another suspected sleep disorder, such as obstructive sleep apnea, narcolepsy, or periodic limb movement disorder (PLMD) (Gradisar et al., 2011).

The primary treatment goal is to re-align the circadian clock with conventional sleep schedules. To do this, typically bright light is provided in the morning, and melatonin is taken in the evening. In a recent meta-analysis that included 40 studies (Faulkner et al., 2019), the authors found that bright light advanced sleep timing, improved sleep quality, and reduced reports of sleep problems. Of interest, avoiding light in the evening was associated with the most improvement in total sleep time. Results were consistent for healthy adults and those with comorbid mental health disorders. Regarding the use of melatonin, it is important in the treatment of DSWPD that melatonin is administered as a chronobiological dose (a low dose given 4–6 hours before bedtime) rather than as a hypnotic (a higher dose given 30–60 minutes before bedtime). A recent systematic review and series of meta-analyses that included 21 RCTs focused on children/adolescents and 13 RCTs focused on adults found that exogenous melatonin was effective in treating DSWPD, and there were no issues related to the tolerability of melatonin (Salanitro et al., 2022). Similarly, van Geijlswijk et al. (2010) concluded that in both adults and children, exogenous melatonin was effective in advancing DLMO and sleep time and reducing sleep-onset latency but did not result in changes in wake time or total sleep time. There is evidence based on seven studies of adults that the combination of bright light therapy in the morning and melatonin at night is more effective in advancing DLMO and improving daytime outcomes than either of these treatments in isolation (Cheng et al., 2021). Another treatment option is chronotherapy (e.g., successively delaying by 2–3 hours per day sleep timing so that sleep timing is moved around the clock until the desired bedtime is reached), although its acceptability to clients is low, it can be disruptive in their lives, and there is limited evidence for effectiveness in adolescents (Gradisar et al., 2011). As such, it has been recommended to use chronotherapy only in severe cases (Micic et al., 2016).

10.3.2.3 What About Treatment of DSWPD in Individuals with ADHD?

Like the treatment of all sleep disorders, most of which have multiple factors contributing to their presentation, the treatment of DSWPD needs to be tailored to the client. However, the core components of the treatment are bright light therapy and exogenous melatonin administration (Micic et al., 2016). These do not differ based on whether or not the individual has ADHD. However, individuals with ADHD may need more support to implement these strategies on a consistent basis. There is a small body of research that has found that stimulant medications may delay the circadian clock (see Sect. 10.1.3). As such, treatment of DSWPD needs to consider whether the individual is being treated with stimulant medications and whether their symptom of DSWPD is secondary to this. It is recommended to consider adjusting the stimulant medication and/or timing of the dose to have less impact on sleep onset. However, if this is not possible or if it does not resolve the DSWPD symptoms, then best practice treatment for DSWPD should be implemented (Chen et al., 2019).

While there is a sizeable body of research that demonstrates the effectiveness of melatonin for sleep problems in individuals with ADHD, most studies are focused on using melatonin as a hypnotic, and little research has examined the use of melatonin as a chronobiologic medication (Coogan & McGowan, 2017). One study in children with ADHD (Van der Heijden et al., 2007) reported the results from an RCT of an evening dose of melatonin, which found that melatonin treatment resulted in advanced sleep-onset time and DLMO. Bright light therapy has also not been extensively evaluated in individuals with ADHD. Gruber et al. (2007) conducted a case study in which the delayed phase was corrected and ADHD symptoms improved with bright morning light. Rybak et al. (2006) found similar results in a small study of 29 adults with ADHD (i.e., advancement in sleep phase, improvement in ADHD symptoms, and improvement in mood symptoms). A recent three-arm clinical trial provided participants (51 adults with ADHD and DSWPD) with healthy sleep habits and 3 weeks of one of three conditions – placebo, melatonin, or melatonin plus bright light (van Andel et al., 2021). Melatonin plus bright light was the most effective condition for advancing sleep time, but melatonin alone was most effective in advancing sleep time and improving ADHD symptoms. These effects dissipated once the treatments were ended.

10.3.3 Restless Legs Syndrome, Periodic Limb Movements in Sleep, and Periodic Limb Movement Disorder

10.3.3.1 What Are Restless Leg Syndrome and Periodic Limb Movement Disorder, Their Prevalence, Etiology, and Impacts?

Restless legs syndrome (RLS) is characterized by an urge to move the legs that is often accompanied with discomfort in the legs. Such discomfort begins or worsens during periods of inactivity but can be partially or totally relieved by movement. RLS symptoms occur exclusively or at least predominantly in the evening/night rather than the daytime (Sateia, 2014). It has been estimated that 5–10% of adults suffer from RLS in the general population, with it being up to two times more prevalent in women than men (Berry & Wagner, 2015). There are many causes of RLS, and they can be divided into two categories. Primary RLS is usually idiopathic and comes from predisposing family factors, such as genetics. Secondary RLS often arises from precipitating factors such as iron deficiency, pregnancy, and renal failures (Berry & Wagner, 2015). Due to its symptoms, RLS is often associated with sleep disturbances, such as prolonged sleep latency and nightly awakenings (Hening, 2004). RLS is often concurrent with periodic limb movements in sleep (PLMS), which are present in 80% of patients with RLS (Montplaisir et al., 1997). However, PLMS does not appear to be the cause of the sleep disorder; rather, sleep disruption is related to RLS symptoms, which delay the return to sleep after an awakening. Indeed, the PLMS index is not correlated with any measure of sleep disturbance (Berry & Wagner, 2015; Hening, 2004). Periodic limb movement disorder (PLMD) arises when PLMS causes clinical sleep disturbances, such as daytime sleepiness and sleep maintenance insomnia (Sateia, 2014). While PLMS is frequently present in patients, PLMD is rarer, so rare that the actual prevalence is unknown (Hornyak et al., 2006).

10.3.3.2 How Are RLS and PLMD Assessed and Treated?

RLS is diagnosed through clinical evaluation, which assesses symptoms and the patient's history. The Cambridge Hopkins Restless Legs Questionnaire contains critical diagnostic questions to evaluate the presence of RLS (Allen et al., 2009). To diagnose a PLMD, the PLMS index must be >5/hour in children and >15/hour in adults. PLMD diagnosis depends on PSG to demonstrate the presence of PLMS, combined with a clinical history to exclude other causes of the symptoms, such as obstructive sleep apnea or RLS. RLS and PLMD cannot be diagnosed together, as a diagnosis of RLS supersedes a PLMD diagnosis.

Treating patients with RLS or PLMD mainly revolves around three options: lifestyle changes, iron supplementation, and medication. Examples of lifestyle changes include recommending the patient incorporate more iron into their diet, exercise more, avoid stimulants such as caffeine, use stress management techniques, and avoid first-generation antihistamines. Even though lifestyle changes are pertinent to propose, they will not be sufficient in cases of severe PLMD or RLS. Clinical guidelines exist regarding pharmacotherapy for RLS (Silber et al., 2021), but not for PLMD since studies on this rare disorder are scarcer. In cases of documented iron deficiency, replacing iron is recommended. The drug treatment trajectories depend on the type of restless leg syndrome (intermittent, chronic/persistent, or refractory RLS). Pharmacologic treatment mainly revolves around dopamine agonists as first-choice molecules, but other medications can be used depending on the characteristics of the patient.

10.3.3.3 What About the Treatment of RLS and PLMD in Individuals with ADHD?

RLS is common in patients with ADHD, with 44% of children diagnosed with ADHD having RLS (Hvolby, 2015). To our knowledge, data on prevalence in adults with ADHD and RLS has not been previously reported, though significant correlations between hyperactivity/impulsivity scores and RLS symptoms have been reported (Snitselaar et al., 2016). Taking these associations into consideration, it is plausible that both of these disorders share pathophysiological similarities. Dopamine and iron dysfunction are the most plausible explanations for the link between these two disorders since they play a role in both ADHD and RLS (Cortese et al., 2009). There is limited data regarding the treatment of co-occurring ADHD and RLS. While data may be limited, three treatment targets stand out in the literature, namely health and lifestyle advice, iron deficiency, and pharmacotherapy (Nixon, 2019). Health and lifestyle advice, such as healthy sleep habits (Picchietti & Picchietti, 2010), exercising, and avoiding caffeine, alcohol, and smoking (Batool-Anwar et al., 2016) can reduce RLS symptoms. Since children with ADHD tend to have reduced peripheral serum ferritin (Tseng et al., 2018) and iron deficiency has a major role in RLS pathophysiology via its role in dopamine neurotransmission (Picchietti & Picchietti, 2010), increasing iron stores through supplements could be an interesting avenue to treat both disorders, but this has yet to be formally studied for patients with comorbid ADHD and RLS (Nixon, 2019).

Regarding pharmaceutical treatment, while many options exist for both disorders, there are no current guidelines for the treatment of concurrent ADHD and RLS. Dopaminergic agents, such as levodopa or pergolide, appear promising for treating RLS symptoms in children while also diminishing ADHD symptoms (Walters et al., 2000). However, another study found only an impact of this medication on RLS symptoms and not on ADHD or sleep parameters (England et al., 2011). While those results are encouraging, the side effects of dopaminergic agents as seen in adults may discourage their use. Such side effects may include increased impulsivity and impaired learning, as well as possible long-term effects on the dopaminergic system (Harris, 2009). Other molecules, such as gabapentin, enacarbil, and clonidine, lack the empirical support to award a frank recommendation for use in patients with concurrent RLS and ADHD (Nixon, 2019). While many treatment options exist for both of these disorders when taken separately, unfortunately, the lack of clear guidelines regarding the treatment of comorbid ADHD and RLS appeals to the physician's caution with its choice of molecule.

10.3.4 ADHD and Other Sleep Disorders

ADHD has inconsistently been reported to have increased rates of sleep breathing disorders, such as obstructive sleep apnea (OSA), and hypersomnolence disorders, such as narcolepsy. It is unclear currently whether these sleep disorders are more common in individuals with ADHD, or if they are an important differential diagnosis. It is clear that individuals with these sleep disorders display high levels of inattention due to daytime sleepiness. An overview of the current knowledge will be presented for both sleep disorders and treatment adaptations for ADHD, if available.

10.3.4.1 Obstructive Sleep Apnea

OSA is the most common breathing disorder and the one that has been the focus of ADHD research (Sciberras, 2022). OSA affects approximately 10% of the general population (Peppard et al., 2013), and is characterized by complete or partial closures of the pharynx during sleep. The obstruction leads to breathing disruptions such as apneas (complete cessation of breathing) or hypopneas (reduced amplitude of airflow), which result in arousal from sleep and fluctuations of oxygen saturation measured by PSG assessment (Berry & Wagner, 2015). OSA severity is defined by the Apnea Hypopnea Index (AHI), and can range from mild (5–15 respiratory events/hours of sleep) to severe (>30 respiratory events/hours of sleep). According to the DSM-5-TR, more than half of patients with moderate to severe OSA report daytime sleepiness (American Psychiatric Association, 2022).

Some research has found that children with ADHD have higher AHI and higher levels of sleep-disordered breathing (SDB) compared to controls (Cortese et al., 2009). Similarly, Sedky et al., 2014 found a moderate association between SBD and ADHD symptoms via their meta-analysis that included 1113 children. However, a review of reviews (Corkum & Coulombe, 2013) did not find a consistent elevation of SDB across studies. A recent retrospective study examined found more severe hypoxia, higher AHI, and more allergic rhinitis in children with concurrent OSA and ADHD compared to OSA alone (Wu et al., 2017). Cortese et al. (2018) hypothesize that inflammatory markers emerging from an allergic reaction could affect the prefrontal cortex and neurotransmitters involved etiologically with ADHD. It has been postulated that the link between OSA and ADHD arises from two components, which are allergic diseases and the dysfunction of the prefrontal cortex, which result from sleep fragmentation and hypoxia due to OSA (Sciberras, 2022).

There are currently no official guidelines regarding the treatment of comorbid OSA and ADHD, but a careful assessment of both conditions can offer the best course of treatment for the patient (Nixon, 2019). There is preliminary data on the effectiveness of adenotonsillectomy (an operation to remove both adenoids and tonsils) for OSA to improve ADHD manifestations in children. Indeed, 50% of children with ADHD who received an adenotonsillectomy no longer met the criteria for a diagnosis of ADHD (Aksu et al., 2015; Chervin et al., 2006). There is also evidence that treating ADHD with stimulant medication and not treating OSA, even if it is only mildly severe, is not effective in reducing daytime drowsiness, poor attention span, and sleep disruption (Huang et al., 2007). When taking these results into consideration, the importance of differential diagnosis is underscored. If, in fact, an individual meets the criteria for both disorders, then it seems appropriate to treat the two conditions at the same time to ensure a reduction in symptoms and a better quality of life for the patient.

10.3.4.2 Narcolepsy

Narcolepsy is a sleep-wake disorder of excessive daytime sleepiness that is considered a hypothalamic disorder with an autoimmune etiology (Bassetti et al., 2021). Narcolepsy is diagnosed using PSG and MSLT, as well as a clinical history. On the MLST, narcolepsy is defined as having a quick sleep onset of an average of <8 minutes and shortened REM sleep latency at least twice across the nap opportunities. In addition to the polysomnographic features, the diagnostic criteria include reports of frequent (i.e., daily) and chronic (i.e., more than 3 months) daytime sleepiness. In type 1 narcolepsy, patients also experience cataplexy (i.e., sudden loss of muscle control ranging from reduction of facial muscle tone to complete muscle paralysis with postural collapse) and abnormal levels of cerebrospinal fluid hypocretin levels. Patients with type 2 narcolepsy do not experience cataplexy.

Narcolepsy is a lifelong disorder that often begins in adolescence. It has significant impacts on the individual's quality of life, productivity, and educational and employment outcomes. There are also high rates of mental health and physical health (e.g., endocrine and metabolic disorders) comorbidities. Many individuals with narcolepsy have difficulties with attention, memory, and daytime fatigue (Gudka et al., 2022). Treatment for narcolepsy includes the implementation of healthy sleep practices, scheduled naps, and psychoeducation (to inform about risks, such as driving). Pharmacotherapy is used to increase alertness (e.g., stimulant medications) and eliminate cataplexy (Maski et al., 2021; Nixon, 2019).

Narcolepsy is a rare sleep-wake disorder with an estimated prevalence of less than 1% (Longstreth et al., 2007). There are high rates of ADHD in patients with narcolepsy. In a recent systematic review, Kim et al. (2020) found that ~30% of narcolepsy patients meet criteria for ADHD. In a clinic-based study by Lopez et al. (2020), which compared adult patients with hypersomnolence to those with ADHD, there were high rates of cross-over symptoms, with 97% of hypersomnolence patients having clinically significant or subthreshold ADHD symptoms (61% and 36%, respectively), and 47% of patients with ADHD having daytime sleepiness. Also, in a retrospective report by adult narcolepsy patients, the rates of ADHD were 8–15 times higher than in the control group (Modestino et al., 2013). More difficulties with alerting attention have been found in type 1 narcolepsy compared to the other types of narcolepsy (Filardi et al., 2017). Importantly, it has been found that treatment of narcolepsy does not significantly improve ADHD symptoms in pediatric narcolepsy patients (Lecendreux et al., 2015). It is not surprising that narcolepsy is often misdiagnosed as ADHD (Goll & Shapiro, 2006; Oosterloo et al., 2006).

10.4 Case Study

Ryan, a 32-year-old male, was referred by his family physician to community mental health for long-standing sleep and attention difficulties that were interfering with his work and home functioning. His family physician indicated that based on a recent physical exam, there were no physical health concerns and no family history of any significant medical problems. It was noted that Ryan was diagnosed with ADHD when he was in Grade 4 and was treated with stimulant medication until Grade 10, at which time Ryan stopped taking the medication due to it "interfering with his social life." Recently, when the family physician suggested that Ryan re-initiate stimulant medication treatment, Ryan stated that he did not believe he had ADHD but rather thought he had a sleep disorder that was causing his attentional difficulties. The referral question was to determine what was causing Ryan's attention and sleep problems and provide treatment to improve his functioning at home and work and overall quality of life.

> Based on the referral information and results of the screening questionnaires, what differential diagnoses are you considering?

As part of the referral, Ryan completed several screening questionnaires. The results of the Conners Adult ADHD Rating Scale (CAARS) self-report form and observer-report form, completed by Ryan's mother, were consistent and highlighted elevated scores on the Behavioral and Emotional Regulation Index, but not on the Cognitive Regulation Index. The results of the PROMIS-43 indicate no concerns in terms of physical functioning, pain interference, or depression, but a clinical elevation on the fatigue and sleep disturbance scales and a non-clinical elevation on the anxiety and ability to participate in social roles and activities scales.

The mental health clinician started the assessment process with a clinical interview. First, he asked for clarification of what brought Ryan to this assessment. Ryan explained that his work contract was not renewed, and as such, he was let go from his job as a project manager at a large hardware store. While his employers were very positive about his ability to interact with clients and staff, lead the team, and generate project ideas and plans, they noted that they had concerns about his follow-through with tasks and his punctuality. Ryan noted that prior to this, he had trained as a carpenter and did well in his vocational training. However, during the program, Ryan hurt his back, and as such, he decided working as a carpenter would not be feasible. After completing the carpentry program, Ryan took an online project management course so that he could work as a project manager in the building sector. Ryan also noted that his partner was often upset with him when he failed to complete household tasks. Ryan reported that he had some close friends with whom he got along well.

Questions further probing his mental health indicated that Ryan's anxiety was related to his work and home challenges and that he was generally not a "worrier." When asked about his previous ADHD diagnosis, Ryan said that he did not agree with the diagnosis as he could concentrate fine when he wanted to. However, he did acknowledge that if the activity was not of high interest, he would often find himself distracted. He also indicated that he had difficulty with organization, especially when he had to multi-task. He did not report any impulsivity or restlessness. When reflecting on ADHD symptoms as a child, he endorsed many ADHD symptoms, but said that these became less problematic when he started trade school.

The clinician asked questions about sleep using BEARS. Regarding his bedtime, he indicated that he goes to bed much earlier on weekdays as he has to be at work for 8 am, which means he has to wake up at 6:30 as he had a 45-minute drive to work. He reported that after supper, he typically watched some TV and played some video games. He would try to be in bed by 10:00 pm, but often it was 11:00 pm before he got into bed. Most nights, he would still be awake at 1:30 am. Ryan reported that he tried everything to sleep, including counting sheep, watching TV, and listening to music. In the morning, he reported that he struggled to get up and would often hit the snooze button five or more times before rushing to get to work. Many days, he would be late for work. On the weekends, Ryan reported that he went to bed at 1:00 am and would take 20–30 minutes to fall asleep. He would sleep until 9:00 am and awaken feeling rested, even though his partner reports that he moves and talks a lot in his sleep. He did not report waking during the night. He does not snore, which his partner confirmed. When asked, Ryan reported that he did not feel overly tired during the day, but at work he would often take a short nap by resting his head on the table at lunch time. He reported that he never falls asleep unexpectedly during the day. The clinician provided Ryan with a sleep diary and asked him to monitor his sleep-wake behaviors for the next 2 weeks and bring the results with him to his next appointment. He also asked Ryan to speak with his mother about his sleep growing up and to report on this at the next session.

> Based on the clinical interview information, what sleep disorders have you ruled out in terms of differentials? What sleep disorders are you considering? Is ADHD still a possible diagnosis?

At his next appointment, Ryan came prepared with his completed sleep diaries. The clinician and Ryan examined these together, and they confirmed much of what Ryan had previously reported: an inconsistent sleep schedule between weekdays and weekends, and some poor sleep practices (e.g., using screens in bed). Because Ryan no longer was working, he was sleeping in later on weekdays and weekends (8:30 on weekdays and 9:30 on weekends) and going to bed later on weekdays, but not weekends (on average: 12:30 am on weekdays and 1:30 am on weekends). It was also noted that there was a lot of variability in his bedtimes (with bedtimes varying by 2–3 hours across the 2 weeks).

Ryan also reported on what his mother told him about his sleep as a child. She said that he was never a good sleeper and, in fact, did not sleep through the night until he was 2 or 3 years old. He had difficulties falling asleep at bedtime and would do lots of "curtain calls." She found the best way for him to get to sleep was to let him sleep in her bed. He did this until he was starting school and then moved back into his own bed, but still struggled to fall asleep. Despite difficulties falling asleep and not sleeping much (Ryan's mother estimated that he slept maybe 7 hours a night during elementary school), Ryan did not seem tired during the day; in fact, he was always moving! She felt that he could not sleep because his mind was racing and he could not settle enough to fall asleep. She also reported that once he started medication for ADHD, it was even harder for him to fall asleep and that he got less sleep on weekdays but would sleep in on weekends to "make up for lost sleep." His mother reported that by the time Ryan was in junior high school, she no longer monitored his sleep as she had to get up early for work and went to bed before Ryan. She reported that she would see him playing video games into the early hours of the morning.

Based on the clinical assessment information, do you think you require any additional information before making a sleep disorder diagnosis? Does Ryan require a PSG assessment? Would you refer him to a sleep specialist? What sleep disorder do you think is most probable, and why? Can you conceptualize Ryan's sleep disorder using a biopsychosocial model? Using the 4P framework, what treatment would you recommend? Do you believe he has ADHD? If so, what treatment would you recommend? Are there any concerns with how his treatment for ADHD could impact his sleep disorder?

10.5 Conclusions

There have been long-standing clinical and research interests in the relationship between ADHD and sleep problems/disorders. Despite consistent clinical observations and self-reports of sleep problems in individuals with ADHD, it has been challenging from a research perspective to consistently identify the exact sleep problems/disorders and determine the underlying mechanism that links sleep and ADHD. Given the multi-dimensional nature of both ADHD and sleep, it is likely that there are numerous relationships, some correlational, some causal, and some related to a third underlying factor.

Based on our literature review, there are some emerging consistent findings that may account for some of the associations between ADHD and sleep, including movement dysregulation, differences in circadian functioning, and differences in the microstructure of sleep. There is also some consistency in the findings that insomnia disorder, delayed sleep-wake phase disorder, and restless legs disorder/periodic limb movement disorder are the most common sleep problems in individuals with ADHD, depending on the developmental stage. It is important that sleep problems be assessed and treated to optimize functioning for individuals with ADHD.

Assessment of sleep problems should occur during the initial diagnostic ADHD assessment, and consideration should be given to sleep problems in terms of differential diagnoses and comorbid diagnoses. Additionally, assessment of sleep problems should happen before and during stimulant medication treatment. Treating sleep problems has been found to improve core ADHD symptoms and overall psychosocial functioning. Treatment approaches for individuals with ADHD are similar to those used for individuals without ADHD. However, some modifications to the content delivery and support for implementation may be needed to ensure adherence and fidelity to the strategies.

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11 ADHD Symptom Malingering and Nonmedical Drug Use in Adults

Sujith Ramachandran, Jeffrey M. Pavlacic, John Young, and John P. Bentley

11.1 Introduction

As delineated throughout this book, attention-deficit/hyperactivity disorder (ADHD) is a complex constellation of difficulties that are often diagnosed in children but may persist throughout the lifespan. In the course of this etiological trajectory, ADHD can often be a risk factor for other issues, which have complex biopsychosocial origins. Two of these issues, malingering of ADHD symptoms and substance use, are critical topics that will be covered in this chapter. The frequency of studies of these two issues has increased substantially in the recent past, potentially due in part to both immediate clinical implications for those affected and epidemiological indication that the non-medical use of prescription stimulants (NMUPS) has seen a precipitous increase. The purpose of this chapter is to provide a thorough review of existing literature for both issues with a focus on implications for clinical practice.

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11.2 ADHD Base Rate and Longitudinal Trends

Prevalence estimates of ADHD diagnosis indicate that between 2% and 14% of children and adolescents meet full diagnostic criteria for ADHD at any given point in time (Fayyad et al., 2017; Mohammadi et al., 2021; Thomas et al., 2015). Averages derived from larger, meta-analytic studies involving global samples suggest a rate of approximately 6% with marked geographical disparities, where high-income countries tend to have higher rates of diagnosis than low- or low-to-middle-income nations (Fayyad et al., 2017). Although some studies have indicated that substantial numbers of these cases are in remission by adulthood (Agnew-Blais et al., 2016; Fayyad et al., 2017; Yoshimasu et al., 2018), other efforts to continuously track individuals longitudinally suggest that this remission is illusory, and that symptoms are consistently problematic but do not always meet full diagnostic criteria at every point in time (Sibley et al., 2022). A systematic review of two decades of literature found that the prevalence of adult ADHD was between 2.58% and 6.76% (Song et al., 2021). Some studies have also reported increasing population-level incidence of ADHD (Xu et al., 2018), although carefully controlled and broad meta-analytic studies have suggested that the base rates did not change significantly over a 30-year period (Polanczky et al., 2014). Consensus among researchers appears to be that

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differences in base rate between studies, localities, and times are attributable primarily to inconsistent use of structured interviews, comprehensive assessment strategies, and diagnostic criteria, as well as increased identification (Polanczky et al., 2014; Sibley et al., 2016).

11.2.1 Malingering

A related problem that may contribute to heterogeneity in rates of diagnosis is malingering. The American Psychiatric Association defines malingering as “the intentional production of false or grossly exaggerated physical or psychological symptoms motivated by external incentives” (APA, 2013). Within the context of ADHD, malingering can be characterized as the exaggeration, falsification, or mischaracterization of symptoms during a clinical assessment for the purpose of seeking a diagnosis. Importantly, this definition of malingering allows it to be distinguished from other types of reporting such as low effort or inconsistencies in symptom reports by the presence of external incentives motivating the behavior. In fact, existing diagnostic models for the identification of malingering of neurocognitive dysfunction often necessitate the presence of a “substantial external incentive” (Slick et al., 1999). As such, the motivations for exaggeration or mischaracterization of ADHD symptoms are perhaps best understood within the context of external incentives, as characterized by the APA.

Malingering of ADHD is documented frequently among college-enrolled young adults, which is perhaps attributable to the unique structure and incentives in the college environment. Individuals with ADHD may qualify for the provision of academic accommodations in a college setting as part of section 504 of the Rehabilitation Act, the Americans with Disabilities Act Amendments Act (ADAAA), and corresponding regulations (Gordon et al., 2015). These accommodations are meant to prevent discrimination, as provision of appropriate academic adjustments and aids can provide an individual an equal opportunity to participate in learning and equitably benefit from educational opportunities (US Department of Education, 2020). This often translates into services such as the provision of additional time for academic assessments, isolated testing environment, provision of learning aids, and other individualized, contextual adaptations for individuals diagnosed with ADHD based on need. Weis et al. (2021) argue that these accommodations are increasingly being made even in the absence of evidence of functional limitations, facilitated by changes in required documentation recommended by the Association on Higher Education and Disability in response to the 2008 amendment to ADA (AHEAD, 2012). In hyper-competitive academic environments, such services may be seen as attractive incentives for individuals without comparable disabilities due to a perception that this offers an advantage in pursuit of academic achievement. Further, seeking out an ADHD diagnosis allows individuals to obtain legitimate (legal) prescriptions for psychostimulant medications. These medications have significant abuse potential allowing individuals who do not have a disability to misuse the medications themselves or divert the prescription with the goal to sell or trade the medications for other services (Clemow & Walker, 2014). In fact, the prevalence of NMUPS, including misuse, diversion, or use in any way not intended by a prescriber, is estimated to be over 30% among college students (Garnier-Dykstra et al., 2012). Taken together, these external incentives are likely to serve as critical motivating factors for malingering of ADHD.

In addition, empirical research has repeatedly demonstrated that malingering of ADHD symptoms is not challenging. ADHD can be faked very easily during direct clinical interviews, on self-report inventories such as the Conners' Adult ADHD Rating Scale (CAARS), Brown Attention Deficit Disorder Scales (BADDS), and the Wender Utah Rating Scale (WURS), observer symptom ratings such as the CAARS-Observer Rating Scale, cognitive measures and even tests of memory, executive function, and attention (Jasinski et al., 2011; Marshall et al., 2010; Jasinski & Ranseen, 2011). Booksh et al. (2010)

found that among individuals instructed to feign ADHD symptoms on a variety of measures, knowledge of ADHD was not related to measure scores. In fact, individuals instructed to feign ADHD performed comparably to those with ADHD, irrespective of whether or not they were provided coaching for their responses (Rios & Morey, 2013; Tucha et al., 2009).

Given the ease of feigning symptoms of ADHD combined with the presence of incentives for malingering, clinicians have cultivated more awareness of the need to pay close attention to self-report of ADHD symptoms. This is especially true because most clinicians are not explicitly trained to detect symptom exaggeration, particularly those without mental health specialty training. Weiner et al. (2013) found that physicians in the emergency room had a sensitivity of 63.2%, specificity of 72.7%, and positive predictive value of 41.2% for identifying drug-seeking behavior (a condition that presents very frequently in this setting, thus providing numerous opportunities for learning and refinement of detection methods). This is potentially not surprising, given that only 19% of practicing physicians reported receiving any training to identify drug diversion behaviors, and only 40% of that small group reported training to identify non-medical use of prescription drugs specifically (Bollinger et al., 2005). In addition, 43% of physicians in this study self-reported that they do not ask about the misuse of drugs of any kind when taking a patient's history (Bollinger et al., 2005).

These practical and conceptual challenges in detecting malingering also make it challenging to obtain reliable and precise estimates of the prevalence of malingering among individuals reporting ADHD symptoms. Suhr et al. (2008) operationalized malingering as a failure on the Word Memory Test (WMT) and found that 31% of young adults reporting symptoms of ADHD met the definition of malingering. Sullivan et al. (2007), using a similar operationalization of malingering, found that 22.4% of individuals evaluated for ADHD or learning disorders may be malingering. Other studies have found prevalence estimates ranging from 14% to 55% (Harrison & Edwards, 2010; Pella et al., 2012; Ramachandran et al., 2020).

11.2.2 Detection of Malingering in ADHD Assessment

Given the prevalence rates of exaggerated ADHD symptom presentations and the ease with which ADHD symptoms are feigned (Berger et al., 2021; Marshall et al., 2021; Nelson & Lovett, 2019; Ramachandran et al., 2019; Tucha et al., 2015), it is imperative that malingering or feigning of ADHD be considered in conducting psychological assessments and interpreting assessment data. While assessment of symptom exaggeration could be considered common practice in comprehensive psychological evaluations, structured diagnostic assessments and screeners are not routinely administered in primary care clinics to assess ADHD symptoms (Adler et al., 2009; Marshall et al., 2021). Lack of structured and comprehensive ADHD assessment perhaps contributes to both overdiagnosis (Paris et al., 2015) and misclassification of ADHD (Booksh et al., 2010; Marshall et al., 2021).

While causes of NMUPS are likely multifaceted, it seems reasonable to conclude that current methods of ADHD assessment (or lack thereof) contribute to elevated rates of NMUPS by increasing accessibility of legally-prescribed medications. As such, this warrants the dissemination of evidence-based assessments to detect malingering and intervention strategies to address NMUPS that can be relatively easily infused in heterogeneous clinical settings. Commonly used assessment methods to detect malingering are outlined below, as are evidence-based recommendations for incorporating brief assessments across different clinical settings to detect exaggerated reporting. Evidence-based intervention strategies (rooted primarily in harm reduction intervention approaches) to address NMUPS are also briefly reviewed, in addition to potential cross-cultural adaptations to evidence-based harm reduction interventions that promote cultural sensitivity in the treatment of NMUPS and associated outcomes. Assessment methods to detect malingering/feigning extend to multiple domains of psychological and neuropsychological functioning and include (1) ADHD symptom checklists, (2) cognitive assessment instruments, and (3) malingering-specific measures designed to determine symptom exaggeration and whether the examinee invests an appropriate amount of effort in producing reliable data.

Regarding ADHD symptom scales, the Conners' Adult ADHD Rating Scales (Conners et al., 1999) and the general adult and childhood ADHD Barkley symptom rating scales (Barkley & Murphy, 2005; Sollman et al., 2010) are commonplace for assessment of ADHD symptoms during the course of psychological evaluations. Despite the utility of using ADHD symptom measures in aiding in the diagnosis of clinical inattention or hyperactivity/impulsivity symptoms, ADHD symptom measures do not necessarily discriminate those with ADHD from those feigning symptoms, and previous studies have indicated that these profiles can be easily faked (Sollman et al., 2010). It can be exceedingly difficult to distinguish genuine clinical ADHD elevations compared to non-clinical presentations through the use of ADHD symptom checklists exclusively, however, which is a prominent issue regardless of the potential for feigning to interfere with accurate assessment (Sagar et al., 2017). In fact, specific adult samples (e.g., undergraduate students) who feign symptoms are readily able to portray symptom profiles consistent with ADHD on ADHD-specific symptom measures (Sollman et al., 2010), thus inappropriately elevating rates of ADHD diagnoses (Potts et al., 2022) and contributing to adverse outcomes. For example, prescriptions for stimulant medication may not necessarily be warranted if diagnosis is based on an exaggerated symptom profile (although future research is needed to solidify this point; see Benson et al., 2015), which could result in a higher potential for personal misuse and diversion of these medications.

As would be perhaps expected given the ability of individuals to overreport ADHD symptoms when completing symptom checklists, as well as the inability of ADHD symptom measures to consistently discriminate between clinical and non-clinical ADHD samples, extant studies have empirically evaluated the utility of various infrequency scales or adapted ADHD symptom measures in attempts to differentiate genuine ADHD profiles from feigned profiles. To provide examples of measures, both the Conners' Infrequency Index (CII; Suhr et al., 2011) and the ADHD Symptom Infrequency Scale (ASIS; Courrégé et al., 2019) show utility for detection of exaggerated symptom reports (Courrégé et al., 2019; Robinson & Rogers, 2018; Suhr et al., 2011) and demonstrate sensitivity to malingering in the case of the ASIS (Courrégé et al., 2019). In its design, the CII classified infrequently endorsed items by individuals with ADHD diagnoses to detect noncredible symptom elevations (i.e., endorsed items that may not be prevalent even in individuals with genuine, albeit self-reported ADHD symptoms), and higher elevations on the CII were significantly and positively associated with non-reliable performance on cognitive measures (Suhr et al., 2011). Additionally, the dissimulation ADHD scale (DS-ADHD; Robinson & Rogers, 2018) captures what the authors refer to as "erroneous" ADHD stereotypes and shows a good ability to discriminate feigned ADHD symptoms compared to genuine ADHD pathology and general feigning.

Regarding measures related to collateral ADHD symptom reports, Lesica et al. (2022) described the development and implementation of the Parent-Reported ADHD Symptom Infrequency Scale (PRASIS). The PRASIS is similar to the CII, except it was designed to differentiate exaggerated vs. more accurate reports of ADHD symptoms in parent reports of their children presenting for ADHD assessments. While psychological assessment instruments do not always reliably determine feigning (Suhr et al., 2008), recent developments in ADHD infrequency scales and ADHD symptom measures provide a basis for assessment instruments that can be included in psychological evaluations. These measures include brief, easy-to-administer measures that could easily be disseminated across various settings to improve screening and assessment processes.

A related assessment strategy that has been employed to detect malingering or feigning aside from using ADHD symptom scales or embedded inconsistency items within symptom scales is the use of cognitive assessment instruments. For example, the Continuous Performance Test (CPT; Conners, 2000), a common assessment of sustained attention that is frequently incorporated into ADHD assessments, can be used to study malingering. Individuals who feign ADHD symptoms show higher levels of impairment on the CPT compared to ADHD patients and healthy controls (Berger et al., 2021). Whereas healthy adults who simulated ADHD symptoms performed worse on all subscales of the MOXO-d-CPT (another proprietary, commercially available version of a CPT). For the MOXO-d-CPT, certain indices (i.e., attention; hyperactivity; impulsivity) were able to discriminate ADHD patients compared to simulators of ADHD. CPTs can be a useful adjunct for the assessment of malingering, given that extreme elevations may be more characteristic of severe neuropsychological deficits (Sollman et al., 2010), which could reflect overreporting instead of ADHD (assuming that there is no evidence of such an extreme neuropsychological deficit on the basis of obtained background history and structured clinical assessment, procedures for which are detailed elsewhere in this book). Specific types of CPTs (i.e., Integrated Visual and Auditory Continuous Performance Tests) are also able to distinguish individuals with ADHD from controls (Quinn, 2003). While results related to the use of CPTs are promising, additional replications are needed to discern whether such assessment methods can be incorporated into research and practice, and their use in the detection of malingering is only burgeoning (Berger et al., 2021).

Aside from infrequency scales, symptom scales, and cognitive tests that have been incorporated into feigning detection assessment strategies, symptom validity tests (SVTs) and performance validity tests (PVTs) provide robust options for detection of exaggerated symptomatology. One commonly used symptom validity test is the Miller-Forensic Assessment of Symptoms Test (M-FAST; Berger et al., 2021; Miller, 2001; Sollman et al., 2010), which was designed primarily to detect feigning of general psychiatric symptoms. Although symptom validity assessments can be incredibly useful for detection of broad exaggeration of symptomatology, these measures are not necessarily specific to the assessment of ADHD or a context where malingering has appetitive contingencies (Sollman et al., 2010). A related validity evaluation strategy, PVTs, assesses whether a respondent is exerting a minimum threshold amount of expected effort for obtained data to be considered both a reliable and valid estimate of an individual's functioning. One commonly used PVT is the Test of Memory Malingering (Tombaugh, 1996), which was designed to distinguish actual memory impairments from exaggerated impairments.

Given the potential utility of both SVTs and PVTs for malingering detection in psychological assessment, measures that fall under the umbrella of SVTs and PVTs have been systematically evaluated. In a meta-analytic review examining the utility of PVTs and SVTs for detection of ADHD feigning, Wallace et al. (2019) showed a large effect size for stand-alone (i.e., assessment instruments that are specifically designed to detect malingering and are administered separately from other measures) and embedded (i.e., subscales of broader instruments that are not necessarily apparent to the respondent) PVTs, although stand-alone instruments exhibited a stronger effect than those that were embedded. In comparing PVTs to SVTs, the results supported PVTs given the large, robust effect, although SVTs still exhibited a medium effect and likely represent a much more efficient, focal means of validity evaluation in many contexts. As discussed by Wallace et al. (2019), the effect sizes for embedded PVTs, stand-alone SVTs, and embedded SVTs are similar but not as strong as those for stand-alone PVTs. While the ability to derive solidified conclusions is limited given that the studies included primarily university samples (which is a common problem in ADHD assessment literature), these results provide support for the incorporation of PVTs and SVTs into the overall evaluation process, particularly when PVTs are administered in a stand-alone format. Still, given the evidence base for embedded tests (e.g., Berger et al., 2021), it is possible that both types of measures can be used simultaneously to assist the clinician in the detection of malingering through the opportunity to evaluate convergence across instruments (see also Rickards et al., 2018, for a decision-tree model involving incorporation of performance validity tests). Similarly, in settings that lack the expertise, time, or availability of other resources for more comprehensive strategies for malingering detection, brief, embedded measures may represent useful tools that improve overall screening and assessment processes.

Finally, there exist some limited instruments that were developed specifically for the identification of malingering of ADHD. These scales were developed using concepts of subtle items which disguise the true psychopathological intent of the questions (Christian et al., 1978). By using a combination of honest respondents with and without ADHD, and individuals instructed to exaggerate symptoms of ADHD, it is possible to select a set of items that are tailored to differentiate these groups (thus potentially identifying malingering by using the items with the most optimal psychometric properties). The Subtle ADHD Malingering Screener (SAMS; Ramachandran et al., 2019) is a good example of such an instrument. It is a brief, 10-item measure, easy to administer and score, and potentially ideal for detection of malingering in the primary care setting, where comprehensive psychological evaluations are not often possible. In the experimental setting, it was found to have a sensitivity of 90.4% and a specificity of 80.1% for the detection of malingering. In a subsequent study, 55% of individuals picking up a prescription for stimulant medications on a college campus were classified as exaggerating their ADHD symptoms per the SAMS (Ramachandran et al., 2020). Another subtle scale, developed by Potts and colleagues using a similar approach, is the Multidimensional ADHD Rating Scale (MARS; Potts et al., 2021). Unlike the SAMS, the MARS includes indices specifically tailored both for the identification of ADHD as well as the detection of malingering. The MARS includes 18 symptom assessment questions and 22 impairment and symptom validity items on 0–8 scale. It includes the Inattention index (I–index), Hyperactivity-Impulsivity index (HI–index), Total Symptom index, Functional Impairment index, and two symptom validity indexes. In the experimental setting, it was found to have 85.7% sensitivity and 65.7% specificity for the detection of ADHD and 79% sensitivity and 89.7% specificity for the detection of malingering. In a subsequent study using a smaller sample, it showed 61.8% sensitivity and 88.2% specificity to malingering (Potts et al., 2022). While both scales have potential applicability in the clinical setting to help improve the diagnosis of ADHD, they need further testing in the clinical setting as part of a well-rounded approach that can allocate appropriate resources to individuals identified as being likely candidates for misdiagnosis.

11.2.3 Implications of ADHD Malingering Assessment for Clinical Practice

In synthesizing findings involving the detection of symptom exaggeration using (1) ADHD symptom and inconsistency scales; (2) cognitive assessments; and (3) measures specific to detect exaggerated symptomatology, meta-analytic reviews appear to support the use of stand-alone PVTs, with smaller yet still meaningful medium-sized effects for SVTs and embedded PVTs. Inconsistency scales embedded in validated ADHD symptom measures also show potential utility for detecting exaggerated symptoms, as do severely impaired profiles on cognitive tests such as the CPT (particularly if such profiles are characteristic of an individual with more severe levels of neuropsychological impairment; e.g., Sollman et al., 2010). Based on the information reviewed above and ADHD research conducted to date, Marshall et al. (2021) recommended a battery incorporating many of the best-practice recommendations for ADHD assessment that could be used in clinical practice, which could be used as a starting point for incorporating malingering assessment measures. They suggested (1) a structured diagnostic assessment; (2) symptom measures completed by both the patient and a collateral reporter (e.g., CAARS); (3) the Test of Variables of Attention (Greenberg et al., 1996; Greenberg, 2011); (4) the Salthouse Listening Span Task (Salthouse & Babcock, 1991); (5) the California Verbal Learning Test-II (CVLT-II; Delis et al., 2000); (6) the DKEFS Color-Word Interference (Delis et al., 2001); and (7) the b test (Boone et al., 2002). This battery provides a comprehensive overview of assessment measures available commercially in the public domain or via emailing corresponding authors (i.e., in the case of the Salthouse Listening Span Task; Marshall et al., 2021). Below, recommendations for potential adaptations to this battery are provided, in line with the malingering literature reviewed.

Regardless of the specific sequelae of measures selected, comprehensive evaluations for ADHD in clinical settings would also ideally integrate PVTs (Wallace et al., 2019), SVTs, inconsistency scales (Suhr et al., 2011), and cognitive measures (Berger et al., 2021) that can be incorporated to detect rare presentations not characteristic of an individual with clinical ADHD symptoms. Inclusion of validity tests should be standard practice in ADHD evaluations (Booksh et al., 2010), yet this is uncommonly addressed in most overviews of the processes for conducting these assessments. The frequently recommended strategy of obtaining collateral information from multiple informants during ADHD assessments (Nelson & Lovett, 2019), however, offers at least some means of recombining data for the purposes of informal evaluation of validity through convergence of reports. In cases where collateral information is gathered, infrequency scales can also be incorporated for external informants to detect exaggerated symptoms (Lesica et al., 2022). If incorporating a cognitive assessment such as a CPT, clinicians should be mindful that certain elevations may be more characteristic of severe neuropsychological impairments (e.g., traumatic brain injury; Sollman et al., 2010) as opposed to ADHD-related psychopathology (presentations that would also likely be extremely apparent to external reporters given their associated functional impairments). As such, cognitive measures should be interpreted judiciously if severe impairments are not necessarily indicated by an in-depth clinical history obtained throughout the structured interview and other information gathered during the assessment process. As should be the case with any comprehensive psychological evaluation, all assessment data should be cohesively integrated and interpreted before providing a diagnosis. Development of empirical approaches to more objectively and focally detect ADHD malingering is a gradual process (Robinson & Rogers, 2018), requiring a high level of care when selecting, administering, and interpreting psychological assessment instruments across multiple domains. The current chapter provides examples of potential adaptations that clinicians could consider to best assess and detect exaggerated reporting.

Within the context of the incorporation of assessment instruments and batteries into psychiatric care or primary care offices, it may be possible for physicians or psychiatrists to incorporate brief screeners designed to detect malingering in their practices (see, for example, Marshall et al., 2021; Ramachandran et al., 2019; Potts et al., 2021), particularly when time is of the essence and delivery of a full psychological battery is not possible. Such clinical settings could recruit a psychological assessor trained to administer comprehensive psychological evaluations if ADHD symptoms are endorsed. Alternatively, malingering screeners or general ADHD symptom screeners can be used as a basis to provide appropriate referrals for a more comprehensive evaluation when ADHD symptoms and/or malingering may be expected. Malingering screeners could also be incorporated into other settings prior to the provision of stimulant medication, such as pharmacies (Ramachandran et al., 2020). When prescriptions for stimulant medications are provided, prescription drug monitoring programs can also be utilized (Plowden et al., 2022), in addition to direct discussion of the dangers of illicit stimulant use prior to starting a stimulant medication.

11.3 ADHD and Substance Use

In the context of ADHD, substance use behavior is typically either related to the non-medical use of stimulants used for treatment or the misuse of other substances (many of which may entail recreational use of illegal drugs). Both domains of behaviors are fairly well documented and associated with known risks of adverse health outcomes but occur in highly variable contexts. For example, the risk of substance use has been studied in the context of ADHD being a risk factor for future behavior, whereas NMUPS is historically studied primarily as misuse of someone else's prescription medication (although this has since been redefined more broadly). Therefore, these behaviors will be described in the following sections separately.

11.3.1 ADHD and the Risk of Substance Use Behavior and Substance Use Disorder

The relationship between ADHD and substance use or substance use disorder (SUD) has been the subject of extensive research. Estimating this relationship can be crucial for clinicians involved in the treatment of ADHD, because ADHD is often co-occurring with several other mental health conditions such as conduct disorder, anxiety disorder, oppositional defiant disorder, and even SUD (Katzman et al., 2017). It is estimated that 25–40% of individuals seeking treatment for SUD have comorbid ADHD (Crunelle et al., 2018; Dirks et al., 2017; Van De Glind et al., 2013; van Emmerik-van Oortmerssen et al., 2012) and 15% of adolescents and young adults with ADHD have SUD (Galán & Humphreys, 2017).

Given the high prevalence of comorbid ADHD and SUD, several longitudinal cohorts have been studied to estimate the potential relationship between ADHD and future SUD. For example, in a 10-year cohort study, Wilens et al. (2011) found that adolescents and children with ADHD had a higher risk of SUD (e.g., alcohol, nicotine, and other drugs) and developed SUD earlier in life than individuals who eventually exhibited similar substance use pathology but did not have diagnoses of ADHD. Children with ADHD have also been shown to be more likely to engage in marijuana use, cigarette smoking, and alcohol use, which was again notable at earlier ages than other youth exhibiting similar behaviors who did not have diagnoses of ADHD (Molina & Pelham Jr, 2003; Molina et al., 2018). A nationally-representative sample of Canadian adults found that ADHD was associated with heavy drug use, heavy smoking, binge drinking, and higher overall likelihood of SUD. Similar findings have been replicated in other countries among college students (Connolly et al., 2019; Garcia et al., 2020). A systematic review found that children with ADHD were more likely than those without ADHD to have a lifetime history of nicotine and marijuana use, and meeting criteria for nicotine dependence, alcohol use disorder, marijuana use disorder, and cocaine dependence (van Amsterdam et al., 2018). Overall, children with ADHD had more than twice the odds of developing general illicit SUD compared to children without ADHD (Lee et al., 2011). Two other meta-analyses of longitudinal studies also showed a similar risk of SUD among children with ADHD (Erskine et al., 2016; Groenman et al., 2017). Howard et al. (2020) followed children with ADHD recruited for a randomized controlled trial for up to 16 years and found that the association between persistent childhood ADHD and adult SUD was mediated by early substance use behavior involving marijuana, cigarettes, illicit drugs, and alcohol.

Further evidence of the causal relationship between ADHD and future SUD is provided by analysis of genomic data. Vilar-Robo et al. (2021) showed that there is a shared genetic risk for ADHD, SUD, cannabis use, and alcohol use disorder. Soler Artigas and colleagues (2020) used genomic analysis from genome-wide association studies for ADHD and found evidence to support the casual relationship between ADHD and lifetime cannabis use. Lambert and Hartsough (1998) first attempted to explain this relationship within a longitudinal cohort study using data from previous animal models. They proposed the sensitization hypothesis, which posited that exposure to methylphenidate or amphetamines in early childhood sensitizes an individual to stimulants and contributes to an increased risk for early adulthood cocaine use disorder. Biederman et al. (2008), however, found that stimulant treatment was not associated with any SUD in a 10-year naturalistic cohort of individuals with ADHD. Further, two studies using large healthcare claims data found that stimulant treatment had a protective effect on the risk of future SUD (Chang et al., 2014; Quinn et al., 2017). In two separate meta-analyses examining prescription stimulant treatment for those with ADHD, no association was found between receipt of stimulants and history of alcohol use, alcohol use disorder, cocaine use and dependence, marijuana use and dependence, and nicotine use and dependence, or any SUD (Humphreys et al., 2013; Wilens et al., 2003). Ivanov et al. (2022) conducted a review of the evidence supporting the sensitization hypothesis and concluded that treatment with stimulant medication is largely protective and the sensitization hypothesis is not likely in any more than a small subgroup of individuals receiving prescription stimulants.

Nevertheless, there is substantial evidence of the causal relationship between ADHD and future SUD. Several studies postulated that this causal relationship may be explained by the increased risky behaviors observed among individuals with ADHD. For instance, ADHD is associated with risk-taking in many contexts such as unsafe sex, driving behavior, gambling, drug use, unhealthy eating, irresponsible financial decisions, and even lead to adverse childhood experiences (Pollak et al., 2019; Hershko et al., 2022; Lugo-Candelas et al., 2021). Such risky behaviors are more common in this population because ADHD causes deficit in attention and executive function, which in turn compromises goal-directed behavior necessary to avoid risk. In fact, Dekkers et al. (2021) found that the increased prevalence of risky behavior among individuals with ADHD is explained by suboptimal decision-making as opposed to risk-seeking attitudes. It is also important to note that some early drug use among individuals with ADHD may be a form of self-medication. Stueber and Cuttler (2022) note that individuals with ADHD often report using cannabis to ameliorate symptoms. Similarly, nicotine dependence may itself be a result of self-medication behavior. Given the evidence supporting the deficits in optimal decision-making and risk of SUD among individuals with ADHD, appropriate early clinical interventions - both pharmacological and psychosocial - are critical in preventing long-term undesirable sequelae.

11.3.2 Non-medical Use of Prescription Stimulants

NMUPS is defined as using prescription stimulants in a way other than what was directly recommended by a prescriber (Arria & Wish, 2006). This can include using stimulant medication prescribed for someone else, using in greater or lesser quantities than prescribed, using in a dosage form not prescribed, or even sharing or selling one’s own prescription (commonly referred to as drug diversion). NMUPS is known to be associated with increased risk of a variety of adverse health outcomes, including weight loss, gastrointestinal distress, insomnia, headaches, irritability, tics, anxiety, anorexia, hallucinations, talkativeness, agitation, anger, paranoia, delusions, personality changes, mood swings, and cardiovascular complications such as hypertension and heart palpitations (Hamilton, 2009; White et al., 2006). In fact, prescription stimulant use is associated with an increased likelihood of both emergency room visits and hospitalizations (Miller et al., 2004). Between 2006 and 2011, ER visits associated with dextroamphetamine-amphetamines increased by 156% among adults (Chen et al., 2016). Between 2005 and 2010, the total number of prescription stimulant-related ER visits have more than doubled, but the visits related to NMUPS specifically have more than tripled, with a majority of this burden being focused among adults as opposed to children (SAMHSA, 2013).

The prevalence of NMUPS is known to be greater among young adults enrolled in college as opposed to any other demographic groups, with estimates ranging anywhere from 5% to 35% in previous studies (Johnston et al., 2014; Whiteside et al., 2015; McCabe & West, 2013; White et al., 2006; Garnier-Dykstra et al., 2012; Wilens et al., 2006; Ramachandran et al., 2019). Garnier-Dysktra and colleagues (2012), for example, found that 31% of students used stimulants without a prescription during a 4-year period enrolled in college. The college student demographic constitutes a high-risk group for NMUPS because the majority of individuals who engage in NMUPS have reported doing so for academic reasons, with over 80% indicating that their motivations were to help with studying, improve memory, or achieve better grades (Faraone et al., 2020). Other reasons for NMUPS include experimentation, weight loss, recreational effects of medication (i.e., "getting high"), increased or decreased effect of other drugs, etc. Paradoxically, previous research does not make it clear that stimulants misused for these purposes are generally effective. Smith and Farah (2011), for example, presented evidence that the cognitive effects of stimulant medications, such as improvements in declarative learning, working memory, and cognitive control, were not highly studied or even well-defined or with reference to the general population of healthy adults. In fact, Arria et al. (2017) found that individuals that initiated or continued NMUPS did not observe any improvement in grades.

Among individuals that engage in NMUPS in a college setting, the most common sources of obtaining medications are friends or family members who have their own prescription (Faraone et al., 2020). These findings converge with research concerning risk factors for malingering and indicate that drug diversion is likely among the most important constructs to study related to NMUPS. Therefore, curbing drug diversion and ensuring individuals with prescriptions for stimulant medications are knowledgeable and engaging in the appropriate use of their medication is a viable approach to help mitigate adverse health consequences associated with NMUPS.

11.4 Harm Reduction Interventions

Given the potential risk of future SUD as well as the risk of NMUPS among individuals with and without ADHD, along with minimizing risk, there are several potential avenues for harm reduction that require the focus of clinicians and public health experts. These avenues are targeted at screening and treatment of SUD comorbid with ADHD, as well as minimizing the risk of drug diversion or non-medical use among those who may be presenting with ADHD symptomology.

A consensus statement of several experts and clinicians involved in the treatment of ADHD states that ADHD is a known and significant risk factor for the development of SUD (Özgen et al., 2020). Therefore, clinicians diagnosing children with ADHD must conduct routine and critical assessment of substance use and drug use behavior. This is particularly important in adolescents, individuals with persistent ADHD, and those with comorbid conduct disorder or oppositional defiant disorders, where the risk of SUD may be greatest (Özgen et al., 2020). Screening for SUD may be conducted using clinical interviews, collateral history, or other reports, where available and must be focused on ensuring the prevention and early treatment of SUD. Importantly, given the abundance of research demonstrating that pharmacological treatment of ADHD may not only be unrelated to the risk of SUD, but in fact decrease the risk of future SUD, it is important that clinicians consider potential treatment as early as possible. Further, because both ADHD and SUD are dynamic conditions, clinicians should not assume that historical diagnosis of either condition continues to be valid during their clinical encounter. While this does not mandate repeat diagnosis of both conditions at each clinical encounter, ongoing treatment with repeated follow-up care and continuity in treatment can result in favorable health outcomes for both conditions.

Given the prevalence of ADHD among individuals with SUD, clinicians treating individuals with SUD need to take special note of potential ADHD symptoms among their patients. Diagnosis of ADHD among individuals with SUD may be challenging because individuals may be seeking care primarily for SUD and may not report or even recall symptoms of ADHD from their childhood. Further, any ADHD symptoms may be misattributed to intoxication or withdrawal of substance use, leading to underdiagnosis. Therefore, guidelines published by the International Collaboration on ADHD and Substance Use report that clinicians should screen SUD patients for ADHD using multiple screening inventories and use collateral history from family or friends along with follow-up assessments to accurately diagnose ADHD (Crunelle et al., 2018). When ADHD is identified among individuals with comorbid SUD, it is critical for clinicians to consider adequate treatment of both ADHD and SUD and consider integrating these treatment regimens wherever feasible. Pharmacotherapy of ADHD among individuals with SUD is challenging because many clinicians may be hesitant to prescribe stimulant medications for individuals with SUD. However, data from randomized controlled trials as well as other studies show that ADHD treatments often have no impact on SUD directly, but they may be effective at mitigating symptoms of ADHD (Levin et al., 2006; Riggs et al., 2011; Schubiner et al., 2002; Winhusen et al., 2010). It is important to consider that individuals with SUD may engage in misuse or diversion of their prescriptions, in which case adequate clinical monitoring as well as prescribing of non-stimulants, or long-acting or extended-release formulations, which have lower rates of misuse (Cassidy et al., 2015), may be recommended. Treatment of individuals with comorbid SUD and ADHD may focus on the treatment of SUD first in order to minimize misattribution of symptoms of SUD or withdrawal with ADHD itself; however, treatment of ADHD symptoms would ideally also start as soon as possible.

Much like the applicability of assessment strategies to detect malingering in clinical settings, harm reduction interventions for NMUPS can be implemented widely and in multimodal formats to maximize dissemination and implementation opportunities across multiple levels, systems, and contexts. In educational and public health settings, for example, interventions that promote raising awareness of the dangers of illicit stimulant use can be provided to the extent appropriate for the setting (Ramachandran et al., 2019), as can interventions focusing on the provision of information regarding the evidence for the use of stimulant medication for promotion of learning outcomes (Smith & Farah, 2011). Campaigns addressing underlying risks for non-medical use of stimulant medications (e.g., Abelman, 2017) could be particularly useful in targeting factors that may lead to aberrant simulant use (and malingering that could potentially be used to gain access to stimulant medications).

In primary care or related medical settings specifically, examples of strategies that could be potentially useful include asking patients about pressures to share stimulant medications with others (Desantis et al., 2013; Faraone et al., 2020) or, more generally, better understanding a patient's social network given the influence that social factors have on NMUPS (e.g., Silvestri & Correia, 2016). In this way, interventions can be tailored to an individual's unique situation and idiographically applied. Additionally, educational and societal interventions could include provision of information regarding peer use of substances, roadside drug testing, among other interventions (see Stockings et al., 2016, for an overview of harm reduction interventions for substance use generally). Taken together, harm reduction interventions should consider preventive and reactionary interventions across multiple levels and systems through contextual modifications.

At the broader sociocultural level, efforts to address cultural beliefs regarding high expectations for university students and achievement (Faraone et al., 2020; Holt & Looby, 2018) more generally (factors that may precipitate NMUPS) could help alleviate the burden that NMUPS causes. Similar to assessment instruments designed to detect malingering, many of the aforementioned interventions are brief and could be incorporated relatively easily into primary care and hospital settings, among other medical settings. Providers may also consider the assessment of cultural values when evaluating NMUPS to better understand idiographic factors that may motivate the use of NMUPS, which could also inform education interventions (particularly those that are culturally sensitive and attune to diverse individual needs).

11.4.1 Implications for Future Research and Clinical Interventions

Directions for future research abound for the assessment of malingering and testing of novel intervention strategies with a harm reduction focus. Regarding assessment of malingering within the context of comprehensive psychological evaluations, testing whether combined validity measures provide stronger sensitivity and specificity may be an appropriate next step in this area of research (Berger et al., 2021; Booksh et al., 2010). Given that many of the conducted studies reviewed here instruct participants to feign symptoms, testing of measures (e.g., SAMS) in real-world environments (e.g., pharmacy settings, primary care clinics; Ramachandran et al., 2020) could also provide additional insight regarding the applicability of such measures in clinical settings. More generally, efforts to expand from participants asked to simulate symptoms (Courrégé et al., 2019; Edmundson et al., 2017) may increase ecological validity. Incorporating ADHD knowledge questionnaires into standard assessment batteries, given the high baseline knowledge for certain populations, may also be useful (Edmundson et al., 2017). While not necessarily ubiquitously connected to feigning, understanding variability in ADHD knowledge could provide insight into how prior knowledge relates to exaggerated symptom reporting. Given that many of the studies reviewed above are conducted with university samples, expansion to collect samples in real-world contexts (Ramachandran et al., 2019; Tucha et al., 2015) and populations is imperative for enhancing generalizability. Additional studies may also examine the development of measures of infrequency for collateral informants of adult samples, as opposed to child samples (e.g., Lesica et al., 2022). Further validation with specific PVTs could also be beneficial in future studies, given the evidence base for PVTs (Wallace et al., 2019).

In terms of clinical interventions, a better understanding of the deterrents of NMUPS could be appropriate for informing evidence-based intervention strategies (Faraone et al., 2020). Cognitive-behavioral strategies designed to target NMUPS could also be broadened to consider the association between social norms and NMUPS, given the influence that these factors appear to exert on such use. At a minimum, examination of whether particular cultural values impact the use of NMUPS and malingering could also be beneficial for better tailoring interventions to the individual.

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12 ADHD and Risk-Taking Behavior: Associations, Mechanisms, and Interventions

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12.1 Section 1: Risk-Taking Behavior

12.1.1 Definition

Risk-taking behavior (RTB) has gained tremendous attention in diverse research disciplines. While all disciplines seek to capture the heterogeneity of people's RTB and identify what underlies it, they bring different concepts of risk into their studies (De Groot & Thurik, 2018; Figner & Weber, 2011; Fox & Tannenbaum, 2011). RTB is also multidimensional, such that different dimensions are prominent in different studies and contexts (Becker et al., 2012). De Groot and Thurik (2018) underscored the need for using precise terminology of risk, pointing at the wrong interpretations and conclusions that inappropriate use could cause.

Non-economic disciplines (e.g., psychology, education, public health, and psychiatry) focus on the potentially adverse outcomes of real-life behaviors as what defines RTB. These disciplines investigate a broad range of behaviors, primarily those likely to lead to severe health outcomes (e.g., substance use, smoking, unprotected sex) (Willoughby et al., 2014). Nevertheless, they narrow the meaning of risk to the potentially devastating outcome range.

The economic literature uses a different definition of risk. Here, RTB is considered any choice of an option associated with variance in the outcome (i.e., where the outcome is unknown), which can be either positive or negative. When the probability distribution governing the unknown outcome is known, the correct term will be *risk*; when the probability distribution of the unknown outcome is unknown, the correct term will be *uncertainty* (or *ambiguity,* in the experimental literature) (De Groot & Thurik, 2018). Notably, according to this definition, most real-life RTB relate to uncertainty, not risk, as the probabilities of the possible outcomes are often unknown. Nevertheless, in this chapter, we will stick to the term RTB even when referring to

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real-life behavior under uncertainty, bearing in mind that the probabilities of the adverse outcome are often unknown. Though studies in the economic literature focus on financial decision-making (where the probability is objective, given in advance, and calculated based on mathematical rules), the economic definition of RTB is broader and based on theoretical decision-making frameworks.

12.1.1.1 Economic Theories

Classical theories of decision-making relate to normative models of risky choice. These models rely on the assumptions of rationality and accord with the laws of probability, and hence, can represent rational thinking. Famous examples of these models include the expected value and expected utility theories (Markowitz, 1952; von Neumann & Morgenstern, 1953).

Expected value theory assumes that people attempt to maximize their expected value in the face of risk. The expected value is the probability of an event multiplied by its objective monetary value, and people are expected to choose the option with the highest expected value. The realization that such expectation does not necessarily reflect people's choices has led to the development of the expected utility theory (Weber, 2010). Expected utility postulates that people wish to optimize their utility, i.e., the probability of an event multiplied by the *subjective utility* of its monetary value (Markowitz, 1952; von Neumann & Morgenstern, 1953).

Studying risk within a theoretical framework while focusing on the decision-making process revealed unique explanations for the heterogeneity of people's risk-taking choices. For instance, the different views of expected value (quantity of money) and expected utility (the utility of that money) draw attention to *decreasing marginal sensitivity* (Tversky & Kahneman, 1992; Weber, 2010) displayed by people in the face of risk. Decreasing marginal sensitivity means that "the first dollar is spent on the most useful commodity, the second on the second-most useful commodity, and so on. Each new dollar brings less extra utility than the one before" (Wakker et al., 2007, p. 205). Consequently, people are risk-averse in the gain domain, i.e., they will prefer a safe option of 10 dollars over a 50 percent chance to win 20 dollars.

Variability in the concept of RTB, with different studies focusing on different aspects of the phenomenon, is reflected in other related terms. For instance, *risk-seeking* describes a preference for a higher-variance option when the expected value is constant (e.g., $50 for sure is preferred to $100 in 50% chance). *Suboptimal decision-making* is considered an irrational choice that violates the mathematical models and leads to non-maximization of value or utility, for instance, choosing an option whose expected value is low or even negative (e.g., preferring not to participate in a lottery of $100 in 50% chance and $0 otherwise). Such observation is essential when comprehending better what makes people take risks. Under uncertainty, such as in real-life, it is a challenge to reveal whether an engagement in RTB reflects risk-seeking or suboptimal decision-making. For example, it is almost impossible to calculate the subjective values and probabilities of all the possible outcomes of smoking cigarettes. Hence, it is hard to determine whether a smoker is risk-seeking or a suboptimal decision-maker. Moreover, in some real-life contexts, *not* engaging in RTB is an irrational or suboptimal choice; for example, refraining from speeding when driving at the speed limit will probably result in arriving too late to a hospital.

To account for heterogeneity in RTB, researchers have introduced other concepts. For instance, *risk attitude* or *propensity* emphasizes the way people approach to risk or individual differences in inclination to take a risk. *Risk perception* or *appraisal* focuses on the subjective evaluation of the risks of various activities (Bran & Vaidis, 2020; Weber et al., 2002). These terms can be interpreted differently according to risk definition or theoretical framework, primarily when related to expected versus non-expected value theories (Bran & Vaidis, 2020; De Groot & Thurik, 2018).

12.1.2 Measures

The literature reveals several major ways to measure RTB: experimental gambling tasks, real-life RTB self-report, hypothetical choice-dilemma problems, and virtual reality. In addition, national registries are often used for examining the prevalence of RTB (especially the consequences of RTB) in large samples.

12.1.2.1 Risk-Taking in Experimental Gambling Tasks

Studying RTB within the economic framework has prominent advantages. The mathematical models organize and parametrize the concept of risk and enable the examination of mental processes that account for RTB.

The most common measures of RTB in the laboratory are *gambling tasks*. These tasks are usually computerized, different in design, and modified to the population by age. In those tasks, participants face two or more options, which vary in their probabilities and values, and their performance is judged by the rationality of their choices (i.e., maximizing utility). RTB is determined by the frequency of choosing the riskier (i.e., higher variance) option. Systematic choice of an option that does not maximize utility might point to irrational subjective evaluation of the amounts or probabilities and violation of the normative model. There are two types of gambling tasks: explicit and implicit (for a review of these tasks in relation to ADHD, also see Groen et al. (2013)).

Explicit Tasks

In explicit (also known as description-based decision) gambling tasks, participants are presented with information regarding all outcomes and probabilities; thus, the strategy to maximize utility is known prior to participants' choices. A popular explicit task is the *Cambridge Gambling Task* (Rogers, 1999), in which participants should determine the amount they wish to gamble given fixed probabilities that are presented descriptively in each trial. The Cambridge Gambling Task distinguishes between making a rational decision, depending on understanding the probabilities, and risk-taking measured by the bet amount. This task makes it possible to estimate how participants' choice patterns vary across clearly defined situations. Another explicit task is the *Game of Dice Task* (Brand et al., 2005). In contrast to the Cambridge Gambling Task, the Game of Dice Task probabilities do not change across trials, and the participants have an opportunity to develop effective long-term strategies.

Other tasks aimed to measure description-based decision-making are the *Make a Match Game* (Drechsler et al., 2010) and the *Probabilistic Discounting Task* (Scheres et al., 2006). Risky behavior is measured by participants' preference for large prizes with variance in outcome over small prizes with a certain outcome. Yet another task aiming to measure risk attitude is the *Clicking Paradigm* (Hertwig et al., 2004). In this task, participants should choose between safe and risky options. The clicking paradigm was modified to measure risk-seeking versus optimal decision-making by presenting safe and risky options while controlling for their expected value (Dekkers et al., 2021a).

Implicit Tasks

In implicit (also known as experience-based decision) gambling tasks, participants are presented with options and should learn their outcomes and probabilities by trial and error. Hence, the task depends on cognitive (e.g., working memory) ability, feedback processing, and motivation. The tasks were designed to simulate the uncertainties of real-life decision-making. The most common task is the Iowa Gambling Task (Bechara et al., 1994). As participants are not provided with any preliminary information, the first choices are made under conditions of ambiguity (uncertainty about probabilities), while successful learning leads to choices based on knowledge of the probabilities and outcomes (Bechara, 2000). Another frequently-used task is the Balloon Analogue Risk Task (Lejuez et al., 2002), in which risk-taking is reinforced to an unknown point where risk-taking abruptly amounts to a poor result.

Though economic research easily parametrizes the concept of risk, such a concept does not align with real-life RTB, in which uncertainty, complexity, and subjectivity are much higher (Mamerow et al., 2016; Szrek et al., 2012). Laboratory gambles are artificial, while real-life choices entail varied risks. The tasks do not appropriately capture daily natural and spontaneous situations; it does not consider content and context that cannot be avoided in real life, which can lead to a different choice pattern in different domains. Additionally, in real life, the risk-taker often can find him/herself in a position that is not expressed in gambling tasks, such as that a particular gain from one domain (e.g., finance) can come at the same time with a loss from another domain (e.g., social rejection) (Blakemore, 2018). Furthermore, risk preferences and attitudes have proven to be inconsistent across different gambling tasks (Lönnqvist et al., 2015; Pedroni et al., 2017).

12.1.2.2 Measuring Real-Life RTB Via Questionnaires

Another form of investigation of RTB focuses on real-life RTB using self-reported questionnaires. In this paradigm, participants provide either the actual frequency of engaging in RTB or the likelihood of engaging in RTB in hypothetical situations. The latter method is necessary for gauging individual differences in the tendency toward RTB where opportunities for engaging in RTB are not available (e.g., participants who have no access to hard drugs).

Specific Behaviors Questionnaires

Many studies focus on *specific behaviors* using detailed standardized questionnaires regarding the frequency of engaging in RTB. The themes of these specific behaviors align with the disciplines of psychology, education, public health, and psychiatry fields of research, which focus on behaviors that are a concern to oneself and others, such as *alcohol use* (e.g., Personal Drinking Habits Questionnaire (Vogel-Sprott, 1992); Alcohol Use Disorders Identification Test (Babor et al., 1992); Alcohol Dependence Scale (Skinner & Horn, 1984); Alcohol Urge Questionnaire (Bohn et al., 1995)), *smoking* (e.g., Alcohol, Smoking, and Substance Involvement Screening Test (Humeniuk et al., 2008)), *substance use* (e.g., Drug Use Screening Inventory (Tarter & Kirisci, 1997)), *sex* (e.g., Sexual Risk Behavior Assessment Schedule (Meyer-Bahlburg et al., 1990); The Sexual Risk-Taking Behavior Scale (Spiegel & Pollak, 2019); Sexual Risk Behavior Scale (Sarver et al., 2014)), and *driving* (e.g., Driver Behavior Questionnaire (Reason et al., 1990)).

Self-report measures are ecologically valid and portray behavioral tendencies across time rather than examining optimal choices in a controlled environment (Van Duijvenvoorde et al., 2016). Nevertheless, criticisms have been drawn regarding their construct validity and reliability, the fact that different studies are focusing on different concepts of RTB, and for not being sensitive to personal biases (Bran & Vaidis, 2020; Fox & Tannenbaum, 2011; Harrison et al., 2005).

Bran and Vaidis (2020) emphasize the need to measure risk-taking across multiple settings, target activities that include active and passive RTB, and consider emotional engagement and potential losses accounting for demographic and clinical characteristics associated with RTB.

Psychological risk-return theories reason that people's decisions are primarily based on their subjective perceptions of the magnitude of riskiness associated with RTB. Considering risk perception as a variable that better captures RTB under uncertainty, the psychological risk-return model provided new measures for accounting for individual differences in people's perceived risk. A famous example of such a measure is the Domain Specific Risk Taking (Weber et al., 2002), a self-report questionnaire testing people's RTB in distinct content areas.

Domain-Specific, Multi, and General Questionnaires

*Domain Specific Risk Taking (DOSPERT; (*Weber et al., 2002*))*: The DOSPERT is a theoretically driven, validated instrument (Shou & Olney, 2020) that initially highlighted domain-specific differences (Weber et al., 2002), but later yielded a domain-general factor as well

(Highhouse et al., 2017). The DOSPERT assesses risk-taking in hypothetical situations in five life domains: health/safety, finance, ethical choices, social interaction, and recreation. Crucially, it can also separate perceptual (how risky behavior is) and attitudinal (how much a person is repelled by his perceived risk) motives of RTB (Weber et al., 2002).

The DOSPERT is widely used. Studies have shown that individuals, groups, and even cultures differ in their perceptions of the risks associated with various behaviors and their assessments of their benefits (Bontempo et al., 1997; Figner & Weber, 2011). The revised version (Blais & Weber, 2006) was translated into various languages (see a complete list of validated translations https://www8.gsb.columbia.edu/decisionsciences/research/tools/dospert). Recently a meta-analysis study elicited cultural heterogeneity in the DOSPERT's internal structure, especially among non-English languages pointing to East Asian cultural groups (Shou & Olney, 2020). The authors stress the indistinctness between domains and the need for more explicit domain specifications. To overcome that and other limitations, researchers have proposed adaptations to the DOSPERT (Shoham et al., 2021a; Shou & Olney, 2020).

Risk-Taking in a Clinical Population

RTB is prevalent in psychiatric conditions such as attention-deficit/hyperactivity disorder (Pollak et al., 2019), trauma (Pat-Horenczyk et al., 2007) and posttraumatic stress disorder (James et al., 2014), conduct disorder (Ramrakha et al., 2007), and personality disorders (Buelow & Brunell, 2014; Ghinea et al., 2019).

The DOSPERT has been used to measure RTB in relation to ADHD (Blankenstein et al., 2021; Shoham et al., 2016). Furthermore, based on the original (Weber et al., 2002) and revised versions (Blais & Weber, 2006) of the DOSPERT, highlighting activities relevant to the functional impairment of ADHD and including updated types of RTB (e.g., social-media related), the adult risk taking inventory (ARTI; Shoham et al., 2021a) questionnaire was developed. The ARTI was designed as a domain-general scale for measuring adult RTB using the framework of decision theory (Sonuga-Barke & Fairchild, 2012; Weber et al., 2002) and its application to clinical psychopathology. The reliability and validity of the scale and its relevance for ADHD-related functional impairment have been demonstrated (Asadi et al., 2021; Shoham et al., 2021a, 2021b).

12.1.2.3 Choice-Dilemma Problems

Propensity to real-life RTB can be measured in the form of choice-dilemma problems. However, this paradigm is mostly used in studies measuring factors (e.g., emotions) that influence the propensity to RTB. This paradigm tests RTB via hypothetical fictitious situations presented as detailed short stories that depict scenarios with uncertain outcomes. In some choice-dilemma problems, participants have to choose between two alternative courses of action – a safe one and a risky one. For instance, "Pub visit: You have been in a new job for a week and enjoy it. On Friday, you overhear people talking about visiting a pub together at the end of work. You would like to get to know your colleagues better, but you have not received an invitation to go along with them. You are unsure whether this is just an oversight or a deliberate snub. On your way home you pass the pub where everyone is meeting and consider whether you should go straight home or call in. They may be very pleased to see you, but it may be embarrassing, and make future work less enjoyable. You wonder what you should do: (A) Go straight home (B) Call in to the pub" (Hockey et al., 2000, pp. 830–831). In others, participants are asked to note the chances of behaving in a described way in a conflicting situation. For instance, "You are on your way to a weekend vacation. A very slow truck is driving just in front of you. A continuous white line separates you from traffic in the opposite direction of the road. What do you think are the chances that you'll go for an overtake?" (Ben-Ari et al., 1999, p.45).

Various behaviors have been studied using choice-dilemma tasks, encompassing activities that might result in adverse physical and non-physical outcomes. An example of detailed scenarios is the Kogan-Wallach choice-dilemma questionnaire (Gambetti & Giusberti, 2009a; Kogan & Wallach, 1964). This scale probes different topics such as health care (e.g., taking unnecessary medications, avoiding health examinations), sex (e.g., safe and protected sex, boundless sexual behavior), extreme sports activities (e.g., skydiving and mountaineering), finance investments (e.g., choosing a security portfolio), driving (e.g., driving through red lights), social activities in personal life and occupational wise (e.g., joining your colleagues to a pub without being invited), and family matters (e.g., accepting a new job that may force you to live separated from your family).

This paradigm has been used for measuring RTB in adults (Ben-Ari et al., 1999; Dahlbäck, 1990; Gambetti & Giusberti, 2009b; Hockey et al., 2000; Kogan & Wallach, 1964; Taubman Ben-Ari et al., 2000) and children (Gambetti & Giusberti, 2009b). It is also used to ask participants to advise another person on which course of action to take while facing a risky situation. The advice is assumed to reflect one's risk attitude or propensity (Kogan & Wallach, 1964). The conceptualization of the choice-dilemma problems remains a challenge since different participants can interpret the stories differently.

12.1.2.4 Virtual Reality Tools

Another measure of RTB uses virtual-reality tools that provide a computer-generated 3D environment in a high resolution. Virtual reality tools simulate situations with natural risks, unlike in self-report questionnaires when participants are remote from the activity and the emotions elicited by the situation (de-Juan-Ripoll et al., 2018). In virtual reality, participants can experience an interactive narrative as if they are in the real world (De-Juan-Ripoll et al., 2021; Tarr & Warren, 2002), and in some measures, they can choose their own adventure (Bran & Vaidis, 2019). The topics can be taken from real-life, such as pedestrian and driving setups (Groom et al., 2015; Hartmann et al., 2017; Nikolas et al., 2016), or from fiction, such as the versions of the spheres and shield maze task (De-Juan-Ripoll et al., 2021). Virtual reality simulation tools enable objective measurements of behavior and real-time physiological measurements such as gaze movement (e.g., eye tracking), thus avoiding subjective bias (Glöckner & Herbold, 2011; Groom et al., 2015). Concerning the current paper, it is interesting that virtual reality simulation tools probing road-traffic RTB (e.g., pedestrian street-crossing, biking, driving) were used to measure ADHD-related RTB. It was found that virtual reality was more sensitive to measuring ADHD-related RTB compared to self-report and experimental tasks (Roberts et al., 2021).

12.1.2.5 Registries

National registries and other population-based databases, where behaviors and consequences of behaviors are being registered, are often used in epidemiological studies. For the purpose of the current paper, a registry is defined as a system that collects clinical and non-clinical observations in a standardized way, which is used to evaluate specified outcomes for a specific population (e.g., people with ADHD) and serves a predetermined clinical purpose (Gliklich et al., 2020). This methodology is very useful for gauging the prevalence of RTB, especially that of the adverse consequences of RTB. For instance, national registries have been employed to examine RTB, such as drug and alcohol use, smoking cigarettes or marijuana, delinquent behaviors, and driving under influence. Other studies measured the rates of the potentially harmful consequences of RTB, such as transport accidents and injuries, convictions and incarceration, obesity, and type 2 diabetes. Obviously, adverse outcomes of RTB may also be caused by non-RTB reasons (e.g., sexually transmitted diseases may be the result of intentional engagement in unprotected sex but might also be the consequence of condom leak).

Using population-based prescription databases is a relatively new approach to studying the effects of medication on RTB. Although not a randomized design, this methodology has several merits, including data on patients from real-world practice, long follow-up time, and large samples. Moreover, this methodology compares the risk of outcomes (e.g., rate of injuries) during medicated and nonmedicated periods (Chang et al., 2019).

12.2 Section 2: The Link Between ADHD and Risk-Taking Behavior

This section reviews research on the link between ADHD and different forms of risk-taking behavior (RTB). Different manifestations of RTB are discussed separately. We discuss meta-analyses, systematic reviews, registry studies, and large prospective studies. For manifestations of RTB where the link with ADHD has not been studied extensively, we also discuss empirical studies with smaller samples. For manifestations of RTB where the link with ADHD was studied very extensively, we selected the most comprehensive meta-analytic reviews.

12.2.1 Substance Use

A meta-analysis including 13 prospective cohort studies following children with and without ADHD ($n = 2067$–3184) into adolescence/adulthood showed that childhood ADHD was linked to nicotine use in adolescence and alcohol use disorder as a young adult (Charach et al., 2011). Associations for other substances were less straightforward as the interpretation of findings was limited by methodological complications. A similar meta-analytic review, including 27 prospective studies ($n \approx 11{,}000$), found that children with ADHD later in life had higher use of all substances except alcohol (Lee et al., 2011). Also, childhood ADHD was associated with nicotine, marijuana, alcohol, cocaine, and other substance abuse/dependence disorders. This meta-analysis concludes that the specificity of the link between ADHD and substance use is unclear because of high rates of comorbidity with disruptive behavior disorders (DBD). A third and more recent meta-analysis, including 23 prospective studies ($n = 22{,}029$), found that childhood ADHD is a prospective risk factor for nicotine, alcohol, and drug use, as well as for substance use disorders (Groenman et al., 2017). Comorbid DBDs did not influence the effect size of the link between ADHD and substance use.

Findings from a recent follow-up of the MTA study ($n = 547$) were in line with the meta-analytic findings reviewed above: Children with ADHD were younger than controls when *using substances for the first time* and demonstrated more *marijuana use* and *cigarette smoking* as adults (Molina et al., 2018). Finally, a Swedish population-based study ($n = 551{,}164$) found that individuals classified with ADHD before 15 years of age were at increased risk for later *substance use disorders*, and this risk was independent of stimulant treatment (Sundquist et al., 2015).

12.2.2 Sexual Risk-Taking Behavior

Three studies showed an association between ADHD and sexual RTB. First, a prospective study that compared young adults with and without childhood ADHD ($n = 286$) found that those with ADHD reported earlier initiation of sexual activity and had more sexual partners, casual sex, and partner pregnancies relative to young adults without childhood ADHD (Flory et al., 2006). This association remained after controlling for comorbid conduct behaviors. Second, a study among 462 young adult women found an association between the mean ADHD symptom score and a sum score reflecting all different sorts of sexual RTB (Hosain et al., 2012). Third, a study among 115 adolescents involved in the juvenile justice system also found a link between sexual RTB (e.g., early sexual debut, HIV testing, >2 sexual partners, casual sex, inconsistent condom use) and ADHD symptoms (Sarver et al., 2014). However, this association was limited to adolescents with high levels of conduct problems and was mediated by substance use problems.

Next to these studies, substantial evidence also links ADHD with the potential *consequences* of sexual RTB. A Taiwanese longitudinal study including 17,898 adolescents and young adults with ADHD and 71,592 controls found that ADHD was a risk factor for subsequent sexually transmitted infections, and this risk was highest in the case of comorbid substance use disorders (Chen et al., 2018a). In men, this risk decreased when ADHD was treated pharmacologically. Also, a Danish historical prospective cohort study ($n = 2{,}698{,}052$; with ADHD: $n = 27{,}479$) found that males and females with ADHD were more likely to become teenage parents than individuals without ADHD (Østergaard et al., 2017). A Swedish nationwide cohort study including 384,103 women (with ADHD: $n = 6410$) indicated more teenage parenthood in those with relative to without ADHD (Skoglund et al., 2019). A Taiwanese longitudinal study including 7505 female adolescents with ADHD and 30,020 controls found that ADHD was a risk factor for pregnancy and early parenthood (Hua et al., 2020). Notably, long-term use of ADHD medication lowered this risk. Finally, a follow-up study on young male and female adults (with a mean age of 20) with and without hyperactive behavior in childhood ($n = 221$) found that having a history of sexually transmitted disease was reported more often by those with relative to without childhood hyperactivity (Barkley et al., 2006).

12.2.3 Driving-Related Risk-Taking Behavior

ADHD is consistently related to RTB in traffic, as well as to the consequences of this behavior. A comprehensive narrative review found that adults with childhood ADHD engaged in more driving-related risk-taking behavior relative to those without childhood ADHD (Barkley & Cox, 2007). More specifically, childhood ADHD was associated with more driving under the influence and more driving without a license, as well as with consequences of driving-related RTB such as more frequent and more severe car crashes and more traffic citations. Furthermore, this review also describes more negative driving outcomes like crashes, license suspension, and traffic citations among adults with relative to without ADHD.

A meta-analytic review including a modest number of studies (maximum of six studies per outcome measure) showed that individuals with ADHD are at increased risk for self-reported motor vehicle collisions, traffic citations, self-reported driving without a license, and self-reported driving under the influence of alcohol (Jerome et al., 2006). A more recent meta-analysis, including 16 studies, reached a more nuanced conclusion: adults with ADHD have a somewhat higher risk of road traffic incidents (relative risk 1.36; Vaa, 2014). This meta-analysis also points out that this risk increases with more comorbid behavioral problems. Furthermore, ADHD was associated with increased speeding violations but not with reckless driving or driving under the influence of alcohol. At the same time, a Swedish national registry study including 17,408 individuals with ADHD found an increased risk of serious transport accidents in this group (adjusted hazard ratio between 1.45 and 1.47), which, in males only, was substantially reduced by ADHD medication (Chang et al., 2014). Similarly, a recent cohort study with a large sample of adolescents/young adults ($n = 18{,}344$; with ADHD $n = 2479$) found a 36% higher crash risk in those with relative to without ADHD (Curry et al., 2017).

12.2.4 Gambling

A meta-analysis including 24 studies demonstrated a significant correlation between ADHD symptoms and gambling severity and found higher odds for individuals with ADHD to have gambling problems and vice versa (Theule et al., 2019). Similarly, a large American population study, including 34,653 adults, showed that those with ADHD had higher odds of gambling problems than those without ADHD (Bernardi et al., 2012).

12.2.5 Financial Risk-Taking Behavior

Although understudied compared to other risk-taking behaviors, the link between ADHD and financial RTB and the consequences of this behavior seems robust. A study on 555 college students (elevated ADHD symptoms: $n = 60$) found that ADHD symptoms were linked to compulsive buying and credit-card misuse (Graziano et al., 2015). A prospective study reported that young adults with hyperactivity in childhood ($n = 149$) reported more problems with saving money than their peers without childhood hyperactivity ($n = 72$), but groups did not differ with regard to loans/debts (Barkley et al., 2006). Finally, a study including 544 adults found an association between ADHD symptoms and debts, late credit card payments, and use of pawn services (Beauchaine et al., 2017). These associations were predominantly driven by the hyperactive/impulsive symptoms of ADHD.

An experimental study showed that adults with ADHD ($n = 45$) had lower scores on standardized tasks probing financial competence and capacity than adults without ADHD ($n = 51$) and reported avoidant (postponing and avoiding decisions) or spontaneous (a desire to make the decision as soon as possible) financial decision-making styles (Bangma et al., 2019).

12.2.6 Eating/Lifestyle

A systematic review including 75 studies concluded that ADHD is related to disordered eating behavior, with a particularly strong association with overeating behavior (Kaisari et al., 2017). Similarly, a large study in Korea, including 12,350 children (7.6% with ADHD), found that ADHD was associated with both bulimic dietary behavior and body mass index (Kim et al., 2014).

As the potential adverse health outcomes of unhealthy diets are common knowledge, it may be considered a food-related form of RTB. Accordingly, a meta-analytic review including 14 cross-sectional studies found that ADHD was linked to unhealthy diets (Del-Ponte et al., 2019).

Most evidence in this area relates to the link between ADHD and the consequences of an unhealthy lifestyle. A meta-analytic review including 728,136 individuals (with ADHD: $n = 48{,}161$) found a significant link between ADHD and obesity in children and adults (Cortese et al., 2016b). Another meta-analysis, including 43 studies ($n = 703{,}937$; with ADHD: $n = 69{,}669$), found a similar association and indicated that this association was larger in adults than children (Nigg et al., 2016). Moreover, a registry study from Sweden, including 2,538,127 individuals (with ADHD: $n = 80{,}009$), demonstrated a higher risk for obesity in individuals with ADHD, with genetic factors strongly contributing to this association (Chen et al., 2018a, 2018b, 2018c). A nationwide longitudinal study in Taiwan, including 107,847 adolescents and young adults (with ADHD: $n = 35{,}949$), showed a higher risk of type 2 diabetes mellitus later in life in those with ADHD (Chen et al., 2018b).

A final line of research shows that ADHD is linked to risk-taking behavior in relation to the COVID-19 pandemic. A survey among 2055 adults in Israel showed that ADHD symptoms were related to poor adherence to preventive measures with regard to the COVID-19 pandemic (Pollak et al., 2021). Relatedly, a large study including 14,022 individuals of all ages found that the prevalence of COVID-19 was higher in untreated individuals with ADHD relative to controls (Merzon et al., 2020).

12.2.7 Delinquency/Aggression

A meta-analysis summarizing 48 effect sizes showed an association between ADHD and criminal/delinquent behavior (Pratt et al., 2002). Therefore, it is not surprising that a meta-analysis of 11 studies, including 15,442 individuals with childhood ADHD, showed that those with ADHD had an increased risk of being arrested, convicted, or incarcerated relative to typically developing controls (Mohr-Jensen & Steinhausen, 2016). A more recent Danish nationwide study following up on children/adolescents in young adulthood confirmed these findings: Those with childhood ADHD ($n = 4231$) were more often convicted and incarcerated than those without childhood ADHD ($n = 19{,}595$) (Mohr-Jensen et al., 2019).

Prevalence rates of ADHD in prison populations are therefore high. A meta-analysis including 42 studies ($n = 26{,}641$; with ADHD: $n = 5677$) found that the prevalence of ADHD was higher in prison populations relative to the general population: five times as high in youth prison populations (30.1%) and 10 times as high in adult prison populations (26.2%) (Young et al., 2015). A more recent meta-analytic review, including 47 studies ($n = 32{,}787$), reported that ADHD was prevalent in 17.3% of juvenile detention/correctional facilities (Beaudry et al., 2021).

12.2.8 Injuries/Premature Death

Risk-taking behaviors often have severe consequences, and ADHD is linked to many adverse health outcomes. First, a Taiwanese cohort study including 52,705 youth with ADHD compared with matched controls found that the probability of burn injury was significantly higher in youth with ADHD relative to controls, with the highest probability in children with ADHD below 6 years old (Yeh et al., 2020). Second, a meta-analytic review consisting of 28 studies, together including more than four million individuals (with ADHD: $n = 350{,}938$), concluded that there is an increased risk for *unintentional physical injuries* in individuals with ADHD relative to those without ADHD (Ruiz-Goikoetxea et al., 2018a). This review also reported that this risk was lower in the case of pharmacological ADHD treatment. Third, another meta-analysis reached a similar conclusion: Pooling effects of 30 studies showed that individuals with ADHD were almost twice as likely to have an *injury* than those without ADHD (Amiri et al., 2017). Fourth, a final meta-analytic review, including nine studies with 84,758 individuals with ADHD and more than one million without, demonstrated that from all types of injuries, ADHD was particularly associated with a higher risk of *poisoning* (Ruiz-Goikoetxea et al., 2018b). Fifth, a study among high school/college athletes ($n = 8056$, with ADHD: $n = 319$) found that those with ADHD were more likely to have a history of at least three *concussions* (Nelson et al., 2016).

A Danish cohort study including 1.92 million people (with ADHD: $n = 32{,}061$) shows a higher mortality rate among individuals with ADHD than those without ADHD (Dalsgaard et al., 2015), with accidents as the most common cause. The risk of premature death increased when ADHD was accompanied by disruptive behavioral or substance use disorders.

12.2.9 Experimental Studies on ADHD and Risk-Taking Behavior

Next to the assessment of real-life risk-taking behaviors as reviewed above, gambling tasks are often used to capture the underlying mechanisms of RTB. In these tasks, participants usually have to choose between multiple options that differ in terms of risk. As reviewed above, many different gambling tasks exist, with considerable heterogeneity among them. Three meta-analyses summarize the differences between individuals with and without ADHD on such tasks, with findings resembling the real-life data summarized above.

First, a meta-analysis including 37 studies ($n = 2397$, 49% with ADHD) on all age groups found that groups with ADHD, on average, made more risky choices than control groups, with a small to medium effect size (Dekkers et al., 2016). Second, a meta-analysis on adults only, including nine studies, yielded a similar conclusion: adults with ADHD, at a group average, showed more experimental risk-taking than controls, with a small effect size (Mowinckel et al., 2015). Third, a more recent meta-analysis on risk-taking using gambling tasks ($n = 5183$, 50% with ADHD), self-report measures ($n = 131{,}804$, 14% with ADHD), and virtual reality measures ($n = 818$, 47% with ADHD) reached a similar conclusion, with largest effect sizes for virtual reality measures (Roberts et al., 2021).

12.3 Section 3: Explaining the Link Between ADHD and Risk-Taking Behavior

What underlies the link between ADHD and higher engagement in RTB? Numerous studies have searched for variables that may elucidate this connection, yielding a long array of explanatory variables. The following section is an effort to summarize the findings and systematize them along the following themes (see Table 12.1).

1. The proposed explanatory factors reflect a variety of research domains and theoretical perspectives such as sociodemographic, clinical, social, personality, cognitive, and biological.
2. Part of the research studied the antecedents of real-life RTB, most often in a specific domain such as smoking and substance use, driving, or sex. As real-life designs have inherent methodological limitations, other studies used experimental laboratory tasks, in which the researcher can control confounding variables and noise and test specific hypotheses. Undoubtedly, laboratory tasks have limited ecological validity. An in-between alternative is virtual reality tasks that seem to include both advantages. Interestingly, a recent meta-analysis revealed a more prominent effect of ADHD when virtual reality measures were used relative to other measures (Roberts et al., 2021).
3. From a methodological point of view, the explanatory variables can be divided into moderators and mediators. Moderators are variables that affect the link between ADHD and RTB or, in other words, interact with ADHD in predicting RTB. On some levels of the moderator, ADHD predicts higher RTB than it does on different levels of the moderator. Another way to phrase it is that moderators reveal for whom and what conditions ADHD predicts RTB. Moderators are often labeled as risk factors (if the moderator's presence increases RTB) or as protective factors (if the moderator's presence decreases RTB). Notably, various factors increase or decrease RTB

Table 12.1 Explanatory variables for the link between ADHD and risk-taking behavior

Domain	Explanatory variable	Real-life/ Experimental	Mediator/Moderator/ General factor	Individual/ Contextual	Bias/ Noise
Sociodemographic	Gender/sex	R, E	Mod	I	B
	Age and puberty	R, E	Mod	I	B
Clinical	ADHD presentation	R, E	Mod	I	B
	Comorbidity	R, E	Mod	I	B
	Academic achievement	R	Med	I	B
Social	Parental monitoring/ knowledge	R	Med, Mod	I	B
	Mother-child relationship	R	Mod	I	B
	Social impairment and peer influence	R, E	Gen, Med	I, C	B
Personality	Impulsivity facets	R	Med, Mod	I	B
	Emotion regulation	R, E	Mod, Med	I, C	B
Cognitive	Executive functions	E	Med	I, C	B
	Delay discounting/aversion	E	Med	I	B
	Risk attitude versus suboptimal decision-making	E	Med	I, C	B, N
	Perceived risk and benefit, expectancies	R	Med	I	B
Biological	Genetics	R	Mod, Med	I	B
	Evolutionary	E	Med	I	B
	Neural	R, E	Med	I	B

without interacting with ADHD, having a similar impact on RTB regardless of the existence of ADHD. These factors are sometimes named independent risk or promotive factors. Although such factors are independent of ADHD, they affect people with ADHD and may be crucial for their treatment.

Mediators are variables that correlate with both ADHD and RTB and provide a causal account for the link: ADHD increases or decreases the mediator, which in turn increases RTB. Importantly, as various studies of the ADHD-RTB link used cross-sectional designs that cannot attest to causal relations, many of these variables should only be considered potential mediators.

4. Some explanatory variables comprise individual differences that predict who is more at risk of RTB (e.g., those who share a genetic risk factor or those whose parents know less about their whereabouts); other variables are contextual differences, which indicate when and under what conditions RTB increases in the same individual (e.g., in the presence of peers). Notably, most research on ADHD and RTB focuses on individual differences, whereas contextual factors have been under-investigated.
5. Most of the explanatory variables identify ADHD with a bias toward risk-taking. Plausibly, if one is about to explain why some people choose to engage in RTB more often than others, she will look for variables that bias choices in that direction. However, an alternative exists, according to which RTB reflects a broader range or variance of behaviors. Consequently, such an explanation suggests that ADHD may be linked to higher engagement in RTB on some occasions but to lower engagement in RTB on other events. In other words, some of the explanatory variables render the behavior of people with ADHD noisier and less predicted.

12.3.1 Sociodemographic Variables

12.3.1.1 Gender/Sex

Participants in a national epidemiologic survey were asked about lifetime risky/impulsive problems (e.g., gambling, reckless driving). ADHD was associated with higher risky/impulsive behavior rates, and gender/sex did not moderate this association (Cortese et al., 2016a). A recent meta-analysis revealed no moderating effect of gender/sex on the link between ADHD and self-reported RTB (Roberts et al., 2021). Similarly, two meta-analyses showed that gender/sex did not moderate the association between ADHD and experimental RTB (Dekkers et al., 2016; Roberts et al., 2021). Notably, the literature about ADHD and RTB has not clearly distinguished between gender as "socially constructed" and sex as "biologically determined."

12.3.1.2 Age

Two meta-analyses have shown that age does not moderate the link between ADHD and RTB in real life and in the laboratory (Dekkers et al., 2016; Roberts et al., 2021). A recent review paper concluded that ADHD intensifies the tendency of adolescents toward risky decisions, though much research is needed to reveal developmental trajectories of ADHD-related RTB (Dekkers et al., 2021b). Interestingly, a small-scale study examined experimental risk-taking in children ages 11–12 and reported that earlier puberty stages were associated with less risk-taking than later stages, regardless of age (Dir et al., 2019).

In summary, the literature suggests that individual differences in gender and age do not moderate the link between ADHD and RTB: the magnitude of the link is similar across genders and ages.

12.3.2 Clinical

12.3.2.1 ADHD Presentation

ADHD comprises two sets of symptoms, inattention and hyperactivity/impulsivity. Accordingly, the DSM-5 lists three presentations of ADHD, predominantly inattentive, hyperactive-impulsive, and combined (American Psychiatric Association, 2013). Studies that examined the specific relations between RTB and ADHD sets of symptoms or diagnostic presentations yielded mixed results. Some studies suggested that hyperactivity/impulsivity is more strongly related to RTB (Lee & Hinshaw, 2006; Shoham et al., 2021a), whereas others suggested that inattention is (Asadi et al., 2021; Isaksson et al., 2018; Molina & Pelham, 2003). One study reported similar effect sizes for inattention and hyperactivity/impulsivity in predicting RTB (Shoham et al., 2016). Another study reported higher engagement in RTB in children with the combined presentation compared to an equally lower level in children with the inattentive or hyperactive/impulsive presentation (who still showed higher levels than controls) (Shi et al., 2021). A meta-regression did not provide conclusive support for differences between ADHD presentations in both real-life and experimental RTB (Roberts et al., 2021). Overall, it can be concluded that RTB relates to both sets of symptoms, though different RTB domains may be more affected by one set of symptoms or the other.

12.3.2.2 Comorbidity

A recent study examined the effect of any psychiatric comorbidity on ADHD-related functional impairment, including risky activities, by comparing 2965 children (age 6–17) with ADHD and psychiatric comorbidity to 2675 children with ADHD without psychiatric comorbidity (Shi et al., 2021). This study found that as the number of comorbidities increased, so did the level of functional impairment for each domain, including risky activities.

Notably, some conduct disorder symptoms constitute RTB in themselves (e.g., aggressive behavior, shoplifting, running away from home). The literature offers mixed answers to whether ADHD without comorbid conditions confers risk for engagement in RTB (see Nigg (2013)). One meta-analysis specifically aimed to disentangle the effects of ADHD on future substance use from the effects of comorbid disruptive behavior disorders (i.e., oppositional defiant disorder, conduct disorder, and antisocial personality disorder) by including only studies ($k = 51$, $n > 1000$) that controlled for the effects of these comorbidities (Serra-Pinheiro et al., 2013). The association between substance use and ADHD was not significant, leading the authors to conclude that ADHD is not a risk factor for substance use beyond comorbid disruptive behavior disorders. However, the ecological validity of this study was questioned (Groenman et al., 2017). Indeed, in a recent meta-analysis, a comparison of effect sizes from real-life RTB studies that included or excluded participants with comorbid disruptive behavior disorders suggested that ADHD-related RTB is not solely attributable to high comorbidity (Roberts et al., 2021).

A review (Groen et al., 2013) and meta-analysis (Dekkers et al., 2016) of laboratory risk-taking tasks reported that studies including more participants with comorbid disruptive behavior disorders tended to have larger effect sizes. No moderating effect of comorbid internalizing disorders (i.e., mood and anxiety disorder) was found. On the other hand, another meta-analysis failed to support a moderating role for disruptive behavior disorders (Roberts et al., 2021).

12.3.2.3 Academic Achievement

A longitudinal mediation analysis revealed that among girls, childhood ADHD predicted lower academic achievement 5 years later, which in turn predicted a higher level of sexual RTB 10 years after the initiation of the study (Owens & Hinshaw, 2019). The authors speculate that low-achieving girls have less opportunity to benefit from sex education or do not see a problem in becoming pregnant because they do not pursue higher education.

12.3.2.4 Self-Medication

Several types of RTB, especially forms of substance use, ameliorate ADHD symptoms and associated mental problems (e.g., stress). Consequently, it has been suggested that behaviors such as smoking are motivated by self-medication and can be understood as such. Support for this account is provided by studies on individuals with ADHD that showed (1) alleviation of ADHD symptoms and improved cognitive functioning and mood regulation following tobacco use, and (2) lower daily smoking associated with stimulant treatment (for review, see van Amsterdam et al. (2018)).

In summary, the literature suggests that individual differences in clinical presentations and functional impairments of ADHD moderate and mediate the link between ADHD and both real-life and experimental RTB. An emphasis has been put on the presence of conduct behavior as a chief promoter of RTB.

12.3.3 Social

12.3.3.1 Parental Monitoring/Knowledge

Adolescence is associated with growing independence, and children, often for the first time, exercise opportunities to act without being observed by adults. Whereas independence is often encouraged by parents and other significant adults, they still act in ways that enable them to know about their child's activities and whereabouts. In a large body of literature, parental knowledge has been linked to lower adolescent RTB (Racz & McMahon, 2011). Several studies examined the role of parental knowledge in protecting against RTB in children with ADHD.

A longitudinal study used latent growth curve modeling to examine whether childhood ADHD predicted alcohol consumption at age 17. Such a link was found only in children with low parental knowledge (Molina et al., 2012). In another study, children with and without ADHD were prospectively followed into adulthood. Results showed that parental knowledge related to lower substance use for all participants but more strongly for adolescents with childhood ADHD (Walther et al., 2012). However, another study failed to find this moderation (García et al., 2021).

Salari and Thorell (2015) demonstrated that parental knowledge was negatively correlated with both ADHD symptoms and norm-breaking behavior, including substance use. A recent study (Dawson et al., 2022) examined the correlations between online RTB (cyber perpetration and victimization, sexting) and parental monitoring among adolescents with ADHD. Parental knowledge of their children's online activities and interactions related to reduced online RTB. Three cross-sectional studies used mediation analysis to examine the relations between ADHD, parental knowledge, and engagement in RTB. Consistently across the studies, ADHD predicted lower parental knowledge, which in turn related to higher engagement in RTB (Dekkers et al., 2021c; Goueta et al., 2021; Pollak et al., 2017), suggesting that lower parental knowledge is a mediator of the link between ADHD and RTB. This suggestion should be further confirmed in longitudinal and intervention studies.

12.3.3.2 Mother–Child Relationship

A study scrutinizing the link between ADHD and sexual RTB among college students examined whether a positive mother–child relationship is a protective factor. It was reported that only for students with ADHD, higher mother–child closeness related to a lower frequency of sex with unfamiliar partners (Huggins et al., 2015).

12.3.3.3 Social Impairment and Peer Influence

A longitudinal study followed the frequency of alcohol consumption of children from age 14 to 17 annually as a function of parental knowledge and problems in relationships with peers. In the high parental knowledge group, ADHD did not confer risk for alcohol use. In the low parental knowledge group, a complex pattern was revealed. On the one hand, a pathway from childhood ADHD to increased alcohol use through peer rejection (and delinquency) was supported; on the other hand, peer rejection that was not associated with delinquency related to decreased alcohol use, suggesting that poor social relationships may guard against exposure to drinking (Molina et al., 2012).

Twin samples were employed to study the longitudinal effect of peer impairment (i.e., low popularity and victimization by peers) at age 14 on tobacco and marijuana problem use at age

17. It was found that peer impairment mediated the effect of ADHD on substance use and that this indirect effect was stronger for males than females (Elkins et al., 2018).

A large study aiming to examine risk and protective factors for substance use among adolescents at-risk found no support for moderation by ADHD on the effects of several risk and protective factors (including parental knowledge) on substance use (García et al., 2021). However, the link between ADHD and marijuana use was moderated by deviant peer affiliation. Deviant peer affiliation was defined by the number of friends that engage in deviant behaviors (e.g., smoking cigarettes, smoking marijuana, drinking, having sexual intercourse, carrying weapons, using cocaine/crack, heroin, and other drugs, selling/delivering drugs, and fighting). It was found that deviant peer affiliation was a more potent risk factor for adolescents with relative to without ADHD.

RTB is influenced by perceived social norms, either descriptive norms, the frequency of RTB in society, or injunctive norms, the level of tolerance toward RTB. In a study conducted on college students, the link between ADHD and alcohol, marijuana, and illicit drug use was significantly mediated by the perceived peer use, i.e., ADHD symptoms were related to higher perceived peer use of the drugs, which in turn predicted higher drug use. Perceived peer tolerance significantly mediated only the link between ADHD symptoms and marijuana use (Van Eck et al., 2014).

In the Pittsburgh ADHD Longitudinal Study (Belendiuk et al., 2016), adolescents with and without ADHD reported their alcohol use and perceived friend alcohol use annually. The results showed that increases in perceived alcohol use related to increases in one's alcohol use over time and that this relation was more substantial for adolescents with ADHD. A subsequent follow-up study examined longitudinal links in young adults through their twenties (Kennedy et al., 2020). Regardless of ADHD history, increases in alcohol use were linked to increased perceived peer use in the subsequent year. In accord with the findings in adolescents, only for participants with ADHD, increasing perceived peer use from ages 18 to 21 predicted more frequent heavy drinking at age 29.

Data from the Multimodal Treatment Study of ADHD (MTA) follow-up was employed to study the longitudinal reciprocal associations of personal and peer-heavy substance use in people with and without ADHD. In general, peer and personal substance use changes followed each other during adolescence and young adulthood. Unexpectedly, several associations were weaker in the ADHD group. The authors suggested that people with ADHD fail to meet normative developmental expectations of detaching their substance use from their peers in their mid-twenties (Kennedy et al., 2019).

Ostensibly, people with ADHD may be more susceptible to peer behavior and attitudes. Wilens et al. (2008) compared the rate of nicotine dependence among late adolescents with and without ADHD. Participants were divided into low- and high-exposure to smoking based on whether their friends and parents smoke and whether they lived with smokers. That study found that higher exposure to smoking predicted higher nicotine dependence only for adolescents with ADHD but not their counterparts. Dekkers et al. (2020) tested the susceptibility to peer influence hypothesis experimentally. Adolescent boys with and without ADHD performed the Balloon Analogue Risk Task solo or under a peer's encouragement to take the risk (using a highly credible virtual peer manipulation). The authors found that both groups showed higher risk-taking in the peer condition, suggesting that susceptibility to peer influence is a general phenomenon and not exaggerated in ADHD. Clearly, more research is needed to reveal whether and under what conditions ADHD is linked to higher susceptibility to influence by peers.

In summary, the literature suggests that individual differences in family and peer relationships moderate and mediate the link between ADHD and real-life RTB. Though theoretically and clinically sound, the hypothesis of ADHD-related higher susceptibility to the peer context has not gained support from studies of experimental RTB.

12.3.4 Personality and Emotion

12.3.4.1 Impulsivity Facets

Several theoretical formulations suggest that impulsivity is a multi-faceted construct. A popular measure of impulsivity facets is the UPPS-P Impulsive Behavior Scale (Lynam et al., 2006). This scale assesses positive urgency (acting impulsively in times of positive affect), negative urgency (acting impulsively in times of negative affect), lack of perseverance (giving up quickly), lack of premeditation (acting without consideration of the consequences of behavior), and sensation-seeking (pursuing activities that are exciting and novel). Studies that explored the relations between ADHD, RTB (e.g., substance use), and the multiple facets of impulsivity found that both ADHD and RTB were associated with most of the impulsivity facets. Furthermore, mediation analyses suggested that negative and positive urgency significantly accounted for part of the link between ADHD and substance use (Egan et al., 2017; Pedersen et al., 2016).

In a sample of undergraduate students, sensation-seeking subscales moderated the relation between ADHD symptoms and over-the-counter stimulants or stimulant medication misuse (Van Eck et al., 2012). Graziano et al. (2015) asked college students to complete self-report questionnaires concerning the levels of ADHD symptoms, sensation-seeking, effortful control (a goal-directed voluntary regulation of emotion and behavior), and RTB (health-related and driving/financial behaviors). Mediation models revealed that ADHD predicted higher sensation-seeking and lowered effortful control levels, which in turn predicted RTB. In another study, the authors formed a personality risk composite score from impulsivity, reward sensitivity, and addictive personality traits scales. They demonstrated that ADHD predicted higher personality risk scores, which in turn predicted higher engagement in addictive behaviors, including recreational drugs and nicotine use (Davis et al., 2015).

Ecological momentary assessment designs have advanced the field by introducing a repeated measure of impulsivity, thus enabling the ecological examination of fluctuations in in-the-moment impulsivity. A recent study used this methodology in adult drinkers with and without ADHD who completed a 10-day, six times/day, momentary assessment of self-reported impulsivity (Pedersen et al., 2019). Participants with ADHD showed more variability in negative urgency, positive urgency, and sensation seeking. Interestingly, positive urgency, negative urgency, and lack of planning predicted alcohol use only in participants with ADHD. These findings highlight the importance of assessing fluctuations in several domains of impulsivity and may elucidate essential treatment targets for alcohol problems for adults with ADHD histories.

12.3.4.2 Emotion and Mood Regulation

Emotional or mood regulation is the psychological process responsible for monitoring and modifying emotions or moods. Numerous studies have scrutinized the relationship between ADHD, emotion regulation problems, and RTB.

Children with and without ADHD were followed up into adolescence (Harty et al., 2017). ADHD was linked to higher parent-reported anger-irritability, which in turn was linked to alcohol use problems, but not binge drinking or drunkenness. The researchers further examined the role of coping strategies used to regulate emotions in moderating the link between ADHD and anger-irritability. It was found that active behavioral and cognitive, but not avoidant, coping moderated that link. The authors concluded that active coping strategies might reduce the tendency of youth with ADHD to alcohol problems through the regulation of negative emotions.

Another longitudinal study on adolescents with and without ADHD found different relations between the same variables. Better emotion regulation skills were associated with better social skills, which in turn were associated with a higher, rather than lower, likelihood of problematic alcohol use. Interestingly, this indirect effect was only present in adolescents whose parents had low knowledge about their whereabouts (Margherio et al., 2020).

In another study, self-reports of ADHD symptoms, RTB (using a domain-general RTB scale), and emotion regulation problems were collected from young adults. First-order correlations among the three variables showed that ADHD symptoms and lower emotion regulation were associated with higher RTB. However, the link between emotional regulation and RTB disappeared when ADHD symptoms were controlled for. On the other hand, the link between ADHD and RTB remained significant after controlling for emotion regulation problems. These findings suggested that the link between ADHD and RTB is not accounted for, at least not entirely, by lower emotion regulation (Asadi et al., 2021).

Using an experimental setting, Loya et al. (2019) tested the effect of frustration induction on RTB (measured by the Balloon Analogue Risk Task) among a small sample of students with higher and lower levels of ADHD symptoms. The results suggested that frustrating contexts lower RTB in students with low ADHD symptoms but not those with high ADHD symptoms.

In summary, the literature suggests that individual differences in impulsivity and emotion regulation moderate and mediate the link between ADHD and real-life RTB.

12.3.5 Cognitive

12.3.5.1 Executive Functions

Executive functions, e.g., inhibition, working memory, and interference control, are the cognitive skills that support goal-directed behavior and decision-making. Barkley et al. (2002) suggested that poor executive function may explain the link between ADHD and risky driving. In a study comparing young adults with and without ADHD, it was found that performance on executive function tasks may account for the link between ADHD and risky driving. However, only a minor proportion of the variance in driving was related to executive functioning (Barkley et al., 2002).

A study that measured the level of motor inhibition among a small sample of male adults with ADHD revealed lower motor inhibition in cocaine-dependent participants than in non-dependent (Crunelle et al., 2013). Another study examined the role of ADHD, methamphetamine dependence, and working memory in explaining RTB on the Iowa Gambling Task. It was demonstrated that only participants with ADHD, methamphetamine dependence, and working memory deficits showed a higher propensity for risky options on the task (Duarte et al., 2012), suggesting that the moderating role of working memory on the link between ADHD and gambling is enabled by substance use.

12.3.5.2 Delay Discounting/Aversion

RTB is defined as a choice of the riskier option. However, the risky option is often the one whose reward is immediate. For instance, the positive outcome of smoking a cigarette is immediate, whereas adverse health outcomes occur years later. Indeed, ADHD has been linked to a steeper delay-discounting pattern of choice, namely, a preference for a smaller, immediate reward over a larger, delayed reward (Jackson & MacKillop, 2016; Marx et al., 2021; Patros et al., 2016). Accordingly, it was suggested that steeper delay discounting might explain why people with ADHD are more likely to engage in RTB. Another delay-related theory aiming to explain ADHD-related behavior is the delay aversion theory, according to which impulsive choices reflect an effort to avoid waiting. Using the Quick Delay Questionnaire, a self-report measure of delay-related behaviors, Thorell et al. (2017) showed that adults with ADHD had higher delay discounting and delay aversion scores. Moreover, they found that delay-related scores predicted substance use and poor money management.

A study that measured delay discounting among a small sample of people with ADHD revealed steeper delay discounting in participants who were also cocaine-dependent (Crunelle et al., 2013). In another study, symptoms of adult ADHD were related to steeper delay discounting and risky financial decision-making such as the use of pawn services (Beauchaine et al., 2017).

These studies suggest that differences in delay discounting may explain the variance in several forms of RTB among people with ADHD.

Sørensen et al. (2017) used the Cambridge Gambling Task to distinguish between different risky decision-making processes. They demonstrated that children with ADHD showed greater delay aversion than control participants; they bet on amounts proposed first, regardless of whether they were proposed in an ascending or descending order. Consequently, children with ADHD bet on higher amounts when they had to wait longer for lower amounts but bet on smaller amounts when they had to wait longer for the higher amounts. Thus, delay aversion may be associated with higher RTB when refraining from RTB demands waiting, but also to lower RTB when engaging in it demands waiting.

Adults completed the Sexual Delay Discounting Task online, reporting their preference for condom use in a hypothetical casual sex scenario as a function of the delay until condom availability. ADHD symptoms predicted steeper delay discounting; those with higher ADHD symptoms preferred immediate unprotected sex more often than those with lower ADHD symptoms. The authors suggested the steeper discounting of delayed condom-protected sex to explain sexual RTB among individuals with high ADHD symptoms (Berry et al., 2020).

12.3.5.3 Risk Attitude Versus Suboptimal Decision-Making

When interpreting RTB, one may distinguish between attitudes and knowledge or perceptions. For instance, adolescents who use drugs may differ from their peers who do not use drugs in their attitudes toward risk. In other words, they may differ in the extent to which the harmful consequences of drug use repel them. Risk attitude is defined as a preference bias toward riskier options, i.e., options with greater variability in outcome. A recent study used a sequential learning test and a hierarchical drift-diffusion model to analyze risk attitude in a small sample of adults with and without ADHD. The results suggested that participants with ADHD had an attitudinal bias toward risky choices (Mandali et al., 2021).

A different interpretation of adolescents' drug use involves cases in which the behavior results from a wrong "calculation" of the value of the options, namely, difficulty in maximizing utility. According to this interpretation, people may choose the risky option not because the risk repels them less but because they do not view this option as less optimal. Several studies suggested that this interpretation may account for ADHD-related RTB (see Pollak et al. (2020) for an overview). For example, when two options were equal in value, but only one was risky, adolescents with and without ADHD were equally likely to choose the risky option (Pollak et al., 2016). This finding was established in two meta-analyses (Dekkers et al., 2021a; Roberts et al., 2021). Furthermore, when the risky option was more optimal than the safe option, people with ADHD were less likely to choose the risky option (Dekkers et al., 2021a, 2019).

Some research endeavored to explain the suboptimal pattern of choices, namely, choosing the riskier option when it is less optimal and choosing the safer option when it is less optimal. Dekkers et al. (2019) used a Bayesian latent mixture analysis to find that adolescents with ADHD were less likely to adopt strategies that integrated all the option characteristics relevant to making an optimal choice. Another study provided evidence that the intra-individual variability in preferences is more considerable in people with ADHD. Accordingly, they are more likely to give more weight to the risk on one occurrence and less weight to the same risk on another occurrence (Pollak et al., 2020).

To make an optimal decision, one often has to learn the probabilistic outcomes of the options. RTB may be accounted for by poor learning that results in believing that a hazardous option is not so risky or that although it is hazardous, it is still better than all other options. ADHD has long been associated with problems in reinforcement learning, i.e., learning which of several options is associated with a better outcome. Often, risk learning is needed as the options are risky, namely, associated with more variance in outcomes (Luman et al., 2010). For instance, a recent study used a Bayesian modeling approach to characterize the pattern of risk learning by adults with and without ADHD. The authors reported that ADHD was associated with less efficient learning, characterized by overhastiness, i.e., the unstable shifting of beliefs after experiencing an immediate reward (Kim & Seo, 2021).

In implicit (experience-based) tasks, risk learning relies on the presence of feedback and its effective usage. On the other hand, in explicit (description-based) tasks, the risks and benefits of the options are known, and relying on feedback is likely to interfere with optimal decision-making. To study whether ADHD is linked to unnecessary reliance on feedback where the risk is known, adolescents with and without ADHD completed an explicit gambling task under one of two conditions, with or without feedback. Adolescents with ADHD made more suboptimal choices only when feedback was provided, suggesting that reliance on unnecessary feedback can explain their tendency to make suboptimal choices (Pollak & Shoham, 2015). In another study, adolescents completed a decision-from-description gambling task with either full or partial feedback (but not without feedback at all). Adolescents with ADHD made more suboptimal choices than controls and performed similarly in the two conditions (Dekkers et al., 2019).

12.3.5.4 Perceived Risk and Benefit

Psychological risk-return theories reason that people's decisions are primarily based on their subjective perceptions of or expectancies concerning the magnitude of riskiness and benefit associated with each option. For example, youth might choose to engage in reckless driving because they perceive the risk as low or the benefits as high. Moreover, according to these theories, subjective perceptions are conscious and can be assessed by self-report (Weber, 2010).

In a sample of undergraduates, the relation between positive expectancies concerning the outcome of alcohol use predicted alcohol-related problem behaviors only for individuals with high ADHD symptoms (Dattilo et al., 2013). In another study, young adults with and without ADHD reported their marijuana expectancies and use. ADHD correlated with lower positive expectancies concerning social enhancement and tension reduction and lower negative expectancies concerning cognitive and behavioral impairment. Interactions between ADHD and specific expectancies were found. Sexual enhancement expectancies predicted higher marijuana use frequency only for individuals with ADHD histories; cognitive behavioral-impairment expectancies predicted lower marijuana use frequency more strongly for individuals without ADHD (Harty et al., 2015). Another study explored the link between ADHD symptoms and positive and negative smoking outcome expectancies. Among adult smokers, higher ADHD symptoms were related to negative smoking expectancies but not positive expectancies (Goldenson et al., 2016).

Shoham et al. (2016, 2020) examined this question in two studies on adults using a domain-general self-report measure of RTB. They showed that ADHD is associated with exaggerated views of the benefits of positive outcomes of risky behaviors but not with unawareness of their risks. Furthermore, a mediation model suggested that the perceived benefits accounted for a significant proportion of the link between ADHD and RTB. Similar findings were found in a study that focused on sexual RTB (Spiegel & Pollak, 2019).

In summary, the literature suggests that individual differences in performance on cognitive and decision-making tasks and in risk and benefit perceptions may mediate and moderate the link between ADHD and both real-life and experimental RTB. Remarkably, the role of the delay between engaging in RTB and experiencing its adverse outcome has been suggested as accounting for ADHD-related RTB. Several lines of evidence suggest that ADHD relates to suboptimal decision-making due to inefficient decision and learning processing and highly-variable preferences. Suboptimal decision-making results in engaging in RTB when it is not optimal but also not engaging in RTB when it is optimal. In other words, ADHD is associated with noisier risk-related decision-making rather than with a bias toward riskier choices.

12.3.6 Biology

Abundant research explores the biological mechanisms underlying the link between ADHD and RTB. Reviewing this literature is beyond the scope of this chapter, and the interested reader may find relevant discussions elsewhere (Slobodin et al., 2015; Sonuga-Barke et al., 2016; Sonuga-Barke & Fairchild, 2012). Here we will focus briefly on several genetic, evolutionary, and neural findings.

12.3.6.1 Genetics

Both ADHD and RTB are heritable and polygenic traits linked by familial coaggregation and shared heritability. For example, large-sample studies demonstrated a substantial genetic correlation between ADHD and the use of alcohol, nicotine, and cannabis, age at first sexual intercourse, and general risk-taking (Du Rietz et al., 2018; Hubel et al., 2019; Luderer et al., 2021; Ni et al., 2019; Soler Artigas et al., 2019; Vilar-Ribó et al., 2020; Vink et al., 2020). Further studies detected specific genetic variants related to ADHD-associated RTB (Meyer et al., 2022; Soler Artigas et al., 2019; Tokko et al., 2022).

12.3.6.2 Evolutionary

ADHD being both highly prevalent and seriously impairing seems paradoxical to natural selection-based models of human evolution. Several resolutions for this paradox have been proposed, all sharing the "mismatch hypothesis" according to which ADHD conferred increased fitness in an ancestral period allowing individuals to survive and pass on their genes (for review, see Thagaard et al. (2016)). Interestingly, some explanations concern the trait of risk-taking as a part of the ADHD phenotype that has been subjected to positive selection. From the individual point of view, ADHD-related sexual RTB may have been subjected to reproduction advantages (Wang et al., 2004). This hypothesis may be supported by the association between ADHD and both sexual RTB and early parenthood (Østergaard et al., 2017). Relatedly, Duell and Steinberg stress that RTB during adolescence serves a developmentally adaptive function and distinguishes between negative (e.g., substance use) and positive RTB (e.g., initiating a new friendship) (Duell & Steinberg, 2019). However, to the best of our knowledge, a link between ADHD and positive RTB is yet to be evidenced. Williams and Taylor (2006) hypothesized that behavioral variability is a central trait of the individual with ADHD and is reflected by exploration, risk-taking, and novelty seeking. Within the social group, a minority of the individuals who share this trait significantly benefit the group's fitness, driving positive selection at the group level. Computational simulations supported this hypothesis (Williams & Taylor, 2006).

12.3.6.3 Neural

Event-related potential studies revealed different neural patterns and circuits involved in ADHD-related experimental RTB. These studies suggested that brain activity markers are sensitive and suited to assess dynamic decision-making processes in ADHD. Moreover, they highlighted the role of reinforcement learning, executive control, and monitoring systems in explaining the link between ADHD and RTB (Ibanez et al., 2012; Mesrobian et al., 2018). In an fMRI study, adults with and without ADHD performed the Iowa Gambling Task. Participants with ADHD had lower orbitofrontal cortical activation, which correlated with poorer performance (Yang et al., 2019).

12.4 Section 4: Interventions

Consider a 15-year-old girl whose tongue froze to a light post when her friends encouraged her to kiss the light post or a 16-year-old girl who dove into a river when her friends cheered her on, despite the sign that warned about the deathly victims that came before her. Some RTB is developmentally appropriate, and researchers have argued that it serves an evolutionary function (Ellis, 2012; Ellis et al., 2012). However, excessive RTB can have fatal consequences, and individuals with ADHD, even more so adolescents with ADHD, have increased tendencies toward RTB compared to those without ADHD (Dekkers et al., 2021b). Therefore, it is useful to consider intervention strategies for excessive RTB in adolescents and adults. Moreover, because ADHD symptoms and diagnosis predate most forms of RTB (e.g., substance use and unprotected sex), ADHD should be considered a promising target for the prevention of future RTB (Nigg, 2013).

Up till now, pharmacological interventions are the only explicit treatments whose effectiveness in reducing RTB has been studied in individuals with ADHD. However, opportunities for non-pharmacological interventions certainly exist. Therefore, below we summarize what is known about the effects of medication on RTB in individuals with ADHD and describe possibilities for non-pharmacological intervention strategies.

12.4.1 Medication

Psychostimulant drugs are the most frequently studied pharmacological intervention in individuals with ADHD (Caye et al., 2019). In terms of reducing real-life RTB, Manuzza et al. (2008) demonstrated in a prospective longitudinal study that individuals with ADHD who started medication treatment at younger ages were less likely to develop non-alcoholic substance use disorders later than those with ADHD who started medication treatment at a later age. Meta-analyses similarly reported that the use of psychostimulant drugs in childhood was associated with lower risks of smoking later on (Schoenfelder et al., 2014; Wilens et al., 2008).

Also, for risky driving, studies report that stimulant use was found to be associated with a reduction in collisions and accidents (Jerome et al., 2006), motor crashes (Chang et al., 2017), and self- and spouse-reported RTB during driving (Jerome & Segal, 2001). In line with this, in a large population study, over 17,000 individuals with ADHD were observed for 3 years for serious traffic accidents reported in Swedish national registers (Chang et al., 2014). The risk of accidents during medication use was lower compared to the risk of accidents during non-medication periods within the same individuals. For male individuals with ADHD (but not for females), the risk of serious traffic accidents (which was elevated compared to individuals without ADHD) was 58% lower during medication than during non-medication. Using a similar approach, Lichtenstein et al. (2012) demonstrated that individuals with ADHD had 32–41% lower rates of criminality during a period of medication use than during periods of non-use.

Chorniy and Kitashima (2016) tracked the health of a large sample of 150,000 children diagnosed with ADHD over 10 years. Compared to the kids with ADHD who were not treated with medication, those who received it were less likely to demonstrate real-life RTB and its consequences. Specifically, the treated group was 2.3% less likely to be injured, 3.6% less likely to contract a sexually transmitted disease, and 7.3% less likely to meet the criteria for substance abuse disorder.

As for experimental laboratory tasks measuring RTB, Dekkers et al. (2016) demonstrated in a meta-regression analysis that ADHD-related risky decision-making was not different in studies in which participants with ADHD were medication-free versus studies in which (a portion of) participants with ADHD used medication. However, follow-up analyses suggested that for the studies in which medication was allowed, ADHD-control differences in risky decision-making were not significant.

All in all, real-life RTB appears to be significantly reduced when individuals with ADHD use psychostimulant medication compared to when they do not. As for risky decision-making, as measured with experimental tasks, results are less conclusive, and more within-participant comparison studies are needed. Using a within-subject double-blind placebo-controlled methylphenidate trial, one such study showed that betting behavior in an explicit gambling task was lower in boys with ADHD when they used medication than when they used a placebo (DeVito et al., 2008).

12.4.2 Intervening in Specific Comorbid RTB

Different individuals with ADHD may take different risks for different reasons. When RTB in adolescents with ADHD expresses specific risky behaviors for which interventions have been developed, these can be used. For example, substance abuse and delinquent behaviors are problems that often co-occur with ADHD and can be viewed as expressions of RTB (Junger & Dekovid, 2003; Pollak et al., 2019). For substance abuse, interventions for adolescents have been developed. Individual-focused approaches have not been successful in reducing substance abuse. For example, drug education programs are ineffective (Ennett et al., 1994), and experts have suggested that adolescents' knowledge may increase, but behavior typically does not change (Steinberg, 2015). On the other hand, successful programs include social competence training in combination with community-wide interventions, including adolescents, peers, and parents (Anderson-Carpenter et al., 2016; Hawkins et al., 2008; Liddle et al., 2009), such as the Community Reinforcement Approach (Meyers et al., 2011) in combination with Motivational Interviewing (Brown et al., 2015). These programs are associated with reductions in adolescent drug use, in particular when these start during the pre-adolescent years. Also, when looking at research that includes adolescents who meet the criteria for drug abuse, programs that include the adolescent's family, and not only the adolescent him/herself, have better chances of resulting in positive change (Liddle et al., 2009). All in all, only focusing on within-person factors is not sufficient when aiming to reduce substance (ab)use in adolescents (with ADHD), and transforming the environment is a necessary ingredient.

As for delinquent behaviors that may exist in the context of a comorbid diagnosis of conduct disorder (<age 18) or antisocial personality disorder (>age 18), once adolescents have started criminal behavior relatively early, the prognosis is not very good, and this behavior is typically the result of a cascade that begins at a young age (Dodge et al., 2008). Therefore, researchers have suggested that early identification and prevention of disrupted family relationships is a key to preventing criminal behaviors (Feilhauer & Cima, 2013; Loeber & Farrington, 2000; Tolan & Gorman-Smith, 2002). Cima further argues that existing interventions focus primarily on un-learning antisocial behaviors and that interventions could benefit from a focus on identifying and strengthening qualities and skills (e.g., collaborating, prosocial skills) (https://www.vigogroep.nl/media/2279/de-pedagoog-3-2020-de-hoogleraar-maaike-cima.pdf). In addition to such early preventative approaches, family interventions (e.g., multisystemic therapy, functional family therapy, multidimensional family therapy) are effective interventions for antisocial adolescents, and these are more effective than interventions that place antisocial adolescents together in groups (Dopp et al., 2014; Lipsey, 2009; Mager et al., 2005; Weiss et al., 2013). Parent interventions specifically developed to modify behavior in children and adolescents with ADHD through reinforcing appropriate behaviors and enhancing parent-child interactions have been shown to significantly reduce conduct problems in children and adolescents with ADHD (see for meta-analyses Daley et al. (2014)).

Taken together, substance abuse and delinquent behaviors in adolescents (with ADHD) require systemic intervention approaches, rather than individual ones, in order for these to be successful. In addition, early prevention is a key to preventing delinquent behaviors.

12.4.3 Interventions Based on Within-Person Mechanisms That Contribute to RTB

Depending on which mechanism(s) is playing a role in the RTB that an adolescent with ADHD demonstrates, different intervention strategies would be needed. For example, if the main explanation for the behavior is that she thinks it is safe (risk perception), a different intervention strategy is needed than when the primary motivation is to prevent social exclusion or when the primary explanation is that she does not think about any potential future consequences. Combinations of intervention strategies may be needed when multiple mechanisms play a role in the RTB.

12.4.3.1 Weak Response Inhibition

As discussed in the previous section, executive function deficits such as weak reponse inhibition, may contribute to the link between ADHD and RTB. In terms of interventions that aim to strengthen response inhibition, Stop-Think-Do methods have been developed (Petersen & Adderley, 2002). In this method, children and adolescents with ADHD learn first to stop, then to think about possible consequences, and then to come up with the best solution or course of action. Only limited evidence of effectiveness has been reported (Antshel & Barkley, 2008). Later, computerized cognitive training was developed. Generally, positive training effects are limited to response inhibition as measured in the training task itself but do not generalize to other inhibition measures or real-life behaviors (Dovis et al., 2015; Kofler et al., 2020). One question is if and how computer training can be adapted to transfer direct training effects to real-life behavior. In order to close the gap between abilities as trained in a computer game and the application of these abilities to real life, intermediate steps that gradually link the game-based skills to real-life may need to be developed. Perhaps, virtual reality could be a method that offers possibilities to this end. For example, Manasse and colleagues recently developed a virtual reality inhibition training task (Manasse et al., 2021). Additionally, full-body games may hold promise (Weerdmeester et al., 2016).

12.4.3.2 Poor Emotion Regulation

While fear is associated with risk-averse choices, anger is associated with risk-seeking choices in real-life situations as well as in experimental settings (Lerner & Keltner, 2001). Therefore, given that ADHD has been associated with weak anger control (Ramirez et al., 1997), interventions specifically focused on anger regulation may help reduce risk-taking behaviors in adolescents with ADHD. Currently, interventions that include emotion regulation strategies are limited to parent training in which parents are taught strategies to support their children and to cognitive behavioral therapy for adults with ADHD (Solanto et al., 2010) (see for an overview (Shaw et al., 2014)). There is a need for interventions tailored for adolescents with ADHD, in which they learn emotion regulation strategies. One promising school-based prevention program that was recently developed to strengthen adolescents' emotion regulation skills and emotional well-being is Boost Camp (Volkaert et al., 2018). Alternatively, current effective programs for adults with ADHD may be adjusted to the specific needs of adolescents. For example, Cole et al. (2016) assessed the effects of a program that included cognitive behavioral therapy and dialectical behavior therapy, which was focused on reducing the burden associated with ADHD symptoms. The program included modules on Mindfulness, Emotion Regulation, Interpersonal Effectiveness, and Distress Tolerance. The program was found to be effective for adults with ADHD, and possibly, this could be tailored toward adolescents with ADHD. Similarly, Solanto's Cognitive Behavioral Therapy for adults with ADHD (2010) includes components on identifying negative thoughts that impact emotional experiences, and it offers strategies to examine and influence these thoughts, with, as a result, changes in the (intensity of) experienced emotions. This intervention may be adapted to meet the needs of adolescents with ADHD.

12.4.3.3 Delay Aversion and Steep Delay Discounting

When adolescents make choices that look risky, temporal decision-making often plays a role as well. Steep delay discounting has been consistently associated with ADHD symptoms in children, adolescents, and adults (Dekkers et al., 2021b; Jackson & MacKillop, 2016; Marx et al., 2021; Patros et al., 2016). In real-life RTB, not only risky decision-making plays a role, but also temporal decision-making, as in weighing the short-term positive effects of behavior against the long-term consequences (e.g., drug use). When steep delay discounting plays a role in real-life risk behaviors, strategies that aim at reducing delay discounting may be useful. Scholten et al. (2019) reviewed the current literature on training and manipulations in this domain (98 studies in total). They found that in 79% of the studies, temporal discounting was decreased through training or manipulation. The most promising training was acceptance-based/mindfulness training, focusing on experiencing and accepting negative experiences during waiting times. Not only was this strategy associated with less discounting on the task, but it was accompanied by improvements in real-life behaviors (eating, using substances, for example). In terms of manipulations, so-called episodic future thinking (vividly imagining the advantages one will experience in the future if one chooses now to forego a small immediate reward in favor of a larger delayed one) was found to be effective in reducing temporal discounting and in improving relevant real-life behaviors. Relatedly, Hershfield and colleagues (2011) used immersive virtual reality to have participants interact with realistic age-processed renderings of their future selves. Interacting with one's future self-increased willingness to save money for the future. This methodology could be used to encourage and support individuals with ADHD toward less risky, more healthy financial decision-making, including adolescents with ADHD. Adolescents have been shown to value the present more than adults in temporal discounting tasks (de Water et al., 2014), and this is exacerbated in adolescents with ADHD (Dekkers et al., 2021b). Therefore, intervening by shifting their focus toward the future and by tolerating negative experiences that may be associated with waiting can reduce real-life behaviors that may look like risky behaviors at first sight but may, in fact, be better interpreted as "now-focused" behaviors.

12.4.3.4 Benefit Perception

Individuals with ADHD tend to endorse the positive aspects of RTB (Bruce et al., 2009; Foster et al., 2012; Shoham et al., 2020; Shoham et al., 2016; Spiegel & Pollak, 2019). Along these lines, recent work in adults with ADHD (Shoham et al., 2020; Shoham et al., 2016) has shown that the link between ADHD symptoms and real-life RTB (for example, driving without a seatbelt) is mediated by the perception of anticipated benefits of the behavior, and not by the perception of anticipated risks. In other words, RTB in individuals with ADHD symptoms can be partly explained by the fact that individuals with ADHD symptoms anticipate greater benefits from risky behavior. Thus, ADHD symptoms are not associated with risk-seeking per se but with the draw/appeal of such risky behaviors. This has implications for interventions, in the sense that the focus should rather be on how individuals with ADHD have a focus on the positive outcomes and not on how they assess the possible risks. One concrete possibility would be that clinicians assist individuals with ADHD in focusing not only on the appealing aspects of the risky behavior but also on the appealing aspects of the less risky alternative. This could result in the development of more fine-tuned decision-making skills.

12.4.4 Interventions That Focus on Adolescent–Environment Interactions

12.4.4.1 Adolescent–Parent Interactions

Previous work showed that parental knowledge mediated the association between ADHD and RTB and that parental knowledge predicts resistance to peer influence (Dekkers et al., 2021c). These two findings together make parental knowledge a potentially relevant mechanism for the intervention or prevention of RTB in adolescents with ADHD. Parental knowledge could potentially be improved by working on the parent-child relationship and improving its quality. Therefore, family therapy, which is often used in adolescents with antisocial behavior, may be suitable for preventing or reducing RTB in general in adolescents (with ADHD). Specifically, a study evaluated the efficacy of a parent-teen driving intervention for adolescents with ADHD, the Supporting the Effective Entry to the Roadway program (Fabiano et al., 2016). Relative to adolescents in a driver education practice program, adolescents in the intervention condition showed lower risky driving levels post-treatment and six months later.

12.4.4.2 Peer Influence and Feedback

Adolescence is a period when individuals (with and without ADHD) are particularly sensitive to feedback from peers (Albert et al., 2013; Ciranka & van den Bos, 2019; Dekkers et al., 2021b). In fact, peer presence can encourage RTB (Gardner & Steinberg, 2005). Following this, one strategy to reduce excessive RTB in adolescents (with ADHD) is to help adolescents resist peer influence. An alternative and potentially more appealing strategy could be to make use of this same peer influence sensitivity in order to reduce RTB. For example, driving games that are currently used to test RTB in the presence of peers or the absence of peers (Gardner & Steinberg, 2005; van Hoorn et al., 2018) could be transformed into training games. In fact, Braams and colleagues (2019) showed that the presence of peers could be used to stimulate choosing the safe option in adolescents. Similarly, van Hoorn et al. (2022) demonstrated that non-impulsive peer feedback was associated with reductions in impulsive decision-making in adolescents with and without ADHD. Such games could be further developed, and adolescents with ADHD could be provided with risk-averse feedback by their peers. Especially popular peers could be selected for this peer influence, and they could be trend-setters by showing other adolescents that they do not take excessive risks. Such a strategy has been used to promote health behaviors among adolescents, such as water consumption (Smit et al., 2021).

12.4.4.3 Contextual Cues

Given that adolescents with ADHD show different brain responses during reward anticipation (Luman et al., 2005; Luman et al., 2010; Plichta & Scheres, 2015), increasing the appeal or attractiveness of less risky options may be a very effective strategy to implicitly invite or nudge adolescents with ADHD toward less risky options. Previous research has shown that healthy food choices can be promoted by making healthy choices more convenient (in terms of seeing the option, picking it up, and consuming it) and attractive (package, brand, price) (Wansink, 2015). Large effect sizes can be reached; for example, children's apple consumption increased by 70% when apples were sliced rather than served as a whole (Wansink et al., 2013). Following this work, Hershko et al. (2020) conducted a study in which university students with and without ADHD rated how appealing pictures of healthy and unhealthy foods were to them. These pictures were manipulated to vary in attractiveness and convenience. The pictures of foods that were manipulated to be attractive and convenient were perceived as more appealing than the pictures that were manipulated to be low in attractiveness and convenience. This effect of attractiveness and convenience on appeal was the same for students with and without ADHD and suggested that such manipulations can be used to nudge people toward healthy food options. Similarly, increasing the attractiveness of non-risky options may be a (cost) effective way of reducing RTB in adolescents (with ADHD). Indeed, in a field experiment by the same group, food choices of university students ($n = 457$) with and without ADHD were observed in a cafeteria. The experiment included three conditions, no advertising, advertising a healthy sandwich located at the customer's eye level, and advertising an unhealthy sandwich located at the customer's eye level. Students with ADHD chose less healthy food items but were more influenced by advertising. Moreover, students with ADHD demonstrated the same overall healthy food choices as controls in the healthy advertising condition, suggesting that unhealthy food choices can be eliminated by advertising (Hershko et al., 2019).

12.4.5 Opportunities for Current Technology in RTB Interventions for Adolescents

12.4.5.1 Virtual Reality

Recently, Roberts et al. (2021) published meta-analyses on RTB in individuals with ADHD, among which eight virtual reality studies. They reported that group differences between ADHD and controls were 30–40% larger in virtual reality studies than in studies using self-reports or experimental tasks (without virtual reality). Given that RTB as related to ADHD can be measured well in virtual reality, this technology may be a suitable context for interventions or training aiming to reduce RTB in individuals with ADHD. However, this work is in its infancy and needs to be developed and tested for its effectiveness. A systematic review and meta-analysis recently reported results over four virtual reality intervention studies in individuals with ADHD (not specifically targeted to RTB, though) (Romero-Ayuso et al., 2021). It was found that virtual reality interventions improved sustained attention, but not impulsivity, in those with ADHD. Its use in interventions to reduce RTB is likely very promising, given that real-life RTB, such as cycling and driving, can be safely and realistically modeled in the lab while using VR. See Bashiri et al. (2017) for a discussion about the possibilities and applicability to individuals with ADHD.

12.5 Conclusions

This chapter reviewed the literature concerning the link between ADHD and risk-taking behavior (RTB). The following points summarize the review's conclusions:

- ADHD is associated with higher engagement in RTB, as defined both clinically (behaviors that increase the likelihood of adverse outcomes, especially in the health domain) and economically (choosing an option with higher variance in outcome).
- In real life, people with ADHD are more likely to engage in substance use, sexual RTB, risky driving, gambling, financial RTB, delinquency, and unhealthy lifestyle. In the laboratory, people with ADHD choose the risky option more often than people without ADHD. The link exists across ages and genders.
- ADHD-related RTB is an essential cause of health, social, and financial impairment. Therefore, it is crucial to address RTB in the evaluation and treatment management of people with ADHD.
- Various clinical (e.g., comorbidity), social (e.g., parental knowledge), personality (e.g., sensation seeking), cognitive (e.g., delay discounting and adoption of ineffective strategies), and biological variables have a moderating and mediating role in the link between ADHD and RTB.
- Most of the explanatory variables are individual differences (e.g., impulsivity, genetics). Some inter-individual variables (e.g., frustration induction) suggest that ADHD is linked to aberrant sensitivity to specific contexts.
- Most of the explanatory variables reflect a bias toward risk-seeking. Some variables instead reflect noisier behavior, i.e., ADHD is associated with greater intra-individual variability in risk-related behaviors, ranging from excessive engagement in RTB in some cases to lower engagement in RTB in other cases. Hence, ADHD is linked to suboptimal decision-making, i.e., choosing the risky option when the safe option is better, but choosing the safe option when the risky option is better.
- Pharmacotherapy has been found effective in reducing several forms of RTB (e.g., drug use, driving, delinquency) in people with ADHD.
- The social, personality, and cognitive explanations of the link between ADHD and RTB reveal a myriad of potential foci for psycho-social interventions. Future studies are warranted to establish the efficacy of these interventions. These may enrich the conceptualizations and tools used for treating people with ADHD.

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13 Conduct Disorder in ADHD

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13.1 Introduction

The prevalence of comorbid psychiatric disorders in children with attention deficit-hyperactivity disorder (ADHD) is generally high and only 13–32.3% of those do not have any psychiatric comorbidity (Ghanizadeh, 2009; Inci et al., 2019; İpçi et al., 2020; Kessler et al., 2006). The high rate of co-occurrence of ADHD with other psychiatric conditions indicates that comorbidity is almost a rule for ADHD and must be elucidated carefully in clinical settings to accurately understand and appropriately manage the treatment of the patient. In addition, the previous literature demonstrated that children with comorbid conditions among ADHD participants often exhibit more severe ADHD symptoms, more enduring course of the disorders, and more severe long-term outcomes (i.e., antisocial personality disorder, delinquency, substance use, academic, occupational, and interpersonal problems) (Barkley, 2014; Booster et al., 2012; Connor et al., 2003; Wåhlstedt et al., 2009). These findings also emphasize the importance of comorbid conditions in ADHD and encourage researchers and clinicians to focus and consider the comorbid conditions in ADHD participants to prevent more severe clinical, behavioral, academic, and interpersonal problems that may result in worse outcomes.

Epidemiological and clinical studies reported that conduct disorder (CD) is one of the most common and devastating forms of comorbidity in children with ADHD (Angold et al., 1999; Costello et al., 2003). Beyond the psychiatric disorders accompanying ADHD, violence, and crime, which have been clearly shown to be associated with CD, were also shown to be related to ADHD (Retz et al., 2021). A meta-analysis revealed a strong link between ADHD and delinquent behaviors (Pratt et al., 2002), and longitudinal studies demonstrated that ADHD significantly elevated the risk for incarceration, conviction, and arrest in adolescents and adults (Barkley et al., 2004; Dalsgaard et al., 2013; De Sanctis et al., 2014; Koisaari et al., 2015; Lam & Ho, 2010; Lundström et al., 2014; Mannuzza et al., 2008; James H Satterfield et al., 2007; Sibley et al., 2011; Silva et al., 2014). Similarly, Mohr-Jensen and Steinhausen reported a significant relationship between childhood ADHD and

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adolescent and adulthood arrests (RR: 2.2, 95% CI: 1.3–3.5), convictions (RR: 3.3, 95% CI: 2.1–5.2), and incarcerations (RR: 2.9, 95% CI: 1.9–4.3) in their meta-analysis of longitudinal studies comprising 15,442 individuals with ADHD (Mohr-Jensen & Steinhausen, 2016). Elevated risk for convictions (OR: 2.01, 95% CI: 1.25–3.24), arrests (OR: 2.43, 95% CI: 1.62–3.65), and incarcerations (OR:2.53, 95% CI: 1.38–4.63) were also found in another meta-analysis in which the estimated odds ratios for drug (OR: 1.69, 95% CI: 0.75–3.77) and violence (OR: 3.63, 95% CI: 2.31–5.70) related arrests were relatively high (Erskine et al., 2016). Furthermore, a four-fold increase in rates of criminal convictions was reported in a large population-based epidemiological study conducted on a sample of adolescents and adults with ADHD in Sweden (Lichtenstein et al., 2012). This literature shows that beyond having comorbid psychiatric disorders, participants with childhood ADHD have an elevated risk of violence and crime in their adolescence and adulthood.

The link between childhood ADHD and violence and crime in later life has been investigated in numerous studies and in the light of these studies, a hypothesis of a developmental pathway between ADHD and crime and violent behaviors has been established from the perspective of developmental psychopathology, which will be discussed in the forthcoming sections of this chapter. To touch on shortly, this hypothesis emphasizes that, in the developmental course of crime and violence, the process begins with ADHD in childhood, and additional conduct problems in adolescence enhance the process which results in antisocial personality in adulthood. Therefore, according to this hypothesis, the CD based on ADHD has crucial importance in the developmental course of antisocial personality, and therefore crime and violence.

In this section, we discuss the comorbidity of ADHD and CD in-depth including the definition of CD, epidemiology of comorbidity of two disorders, possible genetic and environmental etiological factors which could explain their comorbidity, diagnosis, screening and prevention, and interventions that could be effective in the comorbid conditions of two disorders.

13.2 Definition

CD is characterized by a repetitive and persistent pattern of behaviors that violate the societal rules and rights of other people like theft, property damage, and physical aggression toward people or animals (NICE Clinical Guidelines, 2017). Individuals with CD can engage in various antisocial behaviors including bullying, vandalism, lying, and stealing and they are also more likely to engage in delinquency and crime during adolescence and adulthood compared to participants without CD (Frick & Morris, 2004; Moffitt et al., 2008). Typically, the CD begins during middle childhood or early adolescence (Nock et al., 2006), and the classification system describes two types of CD based on the age of onset of symptoms (APA, 2013; Lahey et al., 1998). In DSM-IV, ADHD, CD, and ODD were classified under the title of "Attention Deficit and Disruptive Disorders" which has been changed in DSM-5. Currently, ADHD is classified under the "neurodevelopment disorders" heading, while CD and ODD are classified under the "disruptive, impulse-control, and conduct disorders" heading (APA, 2013).

DSM-5 requires at least 3 of 15 symptoms which were divided into 4 subgroups (i.e., aggression toward people and animals, destruction of property, deceitfulness or theft, and serious violations of rules) to exist at least for 1 year; and at least one symptom to exist for 6 months. DSM-5 defines two subtypes based on the age of onset of symptoms (childhood-onset versus adolescent-onset) and specifies according to the presence or absence of limited prosocial emotions (LPE). Childhood-onset defines the cases with the beginning before the age of 10 and adolescent-onset after the age of 10. The subgroup of LPE defines the individual displaying at least two of the prosocial emotion characteristics (i.e., lack of remorse or guilt; callous—lack of empathy; unconcerned about performance; shallow or deficient affect) persistently over at least 12 months and in multiple relationships and settings. Table 13.1 shows the diagnostic criteria of CD according to DSM-5.

13.3 Epidemiology

13.3.1 Epidemiology of CD

The epidemiological studies report different frequencies of CD based on the methodology and sample of the research. In the majority of epidemiological studies from industrialized Western countries, 5–10% of children and adolescents reported having significant persistent disruptive, aggressive, or oppositional behavior problems (Moffitt & Scott, 2009). DSM-5 reports the prevalence range from 2% to more than 10%, with a median of 4% (APA, 2013), and other reliable sources report that the prevalence elevates throughout childhood and the disorder is more common in boys than girls (the ratio is ½ for girls and boys, respectively) (Sagar et al., 2019). For example, at the ages between 5 and 10, the prevalence is 7% in boys and 3% in girls; in children aged 11–16 years, the proportion increases to 8% in boys and 5% in girls (NICE Clinical Guidelines, 2017). One study reported higher rates of CD among the youth in the United States (i.e., 6–16% in males and 2–9% in females) (Sagar et al., 2019). On the other hand, worldwide prevalence is estimated to be 2–2.5%, with a prevalence of 3–4% in boys and 1–2% in girls, and there is little evidence proposing that the prevalence of the disorder differs between countries (Ercan et al., 2019; Erskine et al., 2013; Polanczyk et al., 2015). CD symptoms typically begin to appear during the middle childhood or early adolescence (Lahey et al., 1998; Nock et al., 2006). Symptoms seem to appear later in girls with a median age of 15 years compared to boys at a median age of 11 years (Sagar et al., 2019). Some studies suggest an increase in the prevalence of CD over recent decades (Barker et al., 2007; Fombonne, 1998); however, others have claimed that no change occurs in prevalence over this period (Erskine et al., 2013). Psychiatric comorbidities are common in CD, such as ADHD, oppositional defiant disorder (ODD), depression, and substance abuse (Sagar et al., 2019). Children with CD have difficulties in education and psychosocial functioning, and they usually confront isolation (Sagar et al., 2019). Despite disappearance of CD symptoms in around 50% of individuals, others have chronic symptoms and develop criminal behaviors and personality disorders in adulthood (Fairchild et al., 2019), and therefore, they cause a very high societal cost to the community (i.e., societal cost for youth with severe CD to the community is estimated to be 10 times higher than those without antisocial problems, and research indicates that the burden of CD surpasses the burden of ADHD and autism spectrum disorder (Erskine et al., 2014; Scott et al., 2001).

13.3.2 Epidemiology of ADHD and Coexisting CD

Disruptive behaviors very frequently coexist with ADHD, and CD is one of the most common coexistent psychiatric disorders accompanying ADHD. According to epidemiological studies, children with ADHD are 11 times more likely to develop comorbid disruptive behavior disorders compared to those without ADHD, and children with CD have a 10 times higher risk of having ADHD than those without CD (Angold et al., 1999). ADHD co-occurs with disruptive behavior disorders including ODD and CD in 30–50% of children (Angold et al., 1999; Costello et al., 2003; Yoshimasu et al., 2012). CD was found to be the most prevalent comorbid psychiatric disorder in children with ADHD in a study conducted in a sample from the US reporting that 27.4% of the children with ADHD have an additional CD (Mohammadi et al., 2021). Biederman reported that the estimated comorbidity rate of ADHD with CD is between 16% and 20%, and comorbidity is more common in boys than in girls (Joseph Biederman et al., 2002). A study from Iran reports a higher rate of CD (60.5%) among children with ADHD (Ghanizadeh et al., 2008). Likewise, a high prevalence of CD in ADHD (57%) has been reported in a study that is one of

Table 13.1 DSM 5 criteria for conduct disorder

A. A repetitive and persistent pattern of behavior in which the basic rights of others or major age-appropriate societal norms or rules are violated, as manifested by the presence of at least three of the following 15 criteria in the past 12 months from any of the categories below, with at least one criterion present in the past 6 months:

Aggression to People and Animals

1. Often bullies, threatens, or intimidates others.
2. Often initiates physical fights.
3. Has used a weapon that can cause serious physical harm to others (e.g., a bat, brick, broken bottle, knife, or gun).
4. Has been physically cruel to people.
5. Has been physically cruel to animals.
6. Has stolen while confronting a victim (e.g., mugging, purse snatching, extortion, armed robbery).
7. Has forced someone into sexual activity.

Destruction of Property

8. Has deliberately engaged in fire setting with the intention of causing serious damage.
9. Has deliberately destroyed others' property (other than by fire setting).

Deceitfulness or Theft

10. Has broken into someone else's house, building, or car.
11. Often lies to obtain goods or favors or to avoid obligations (i.e., "cons" others).
12. Has stolen items of nontrivial value without confronting a victim (e.g., shoplifting, but without breaking and entering; forgery).

Serious Violations of Rules

13. Often stays out at night despite parental prohibitions, beginning before the age of 13.
14. Has run away from home overnight at least twice while living in the parental or parental surrogate home, or once without returning for a lengthy period.
15. Is often truant from school, beginning before the age of 13.

B. The disturbance in behavior causes clinically significant impairment in social, academic, or occupational functioning.

C. If the individual is 18 years or older, criteria are not met for antisocial personality disorder.

Specify whether:

Childhood-onset type: Individuals show at least one symptom characteristic of conduct disorder prior to the age of 10.

Adolescent-onset type: Individuals show no symptom characteristic of conduct disorder prior to the age of 10.

Unspecified onset: Criteria for a diagnosis of conduct disorder are met, but there is not enough information available to determine whether the onset of the first symptom was before or after the age of 10.

Specify if:

With limited prosocial emotions: To qualify for this specifier, an individual must have displayed at least two of the following characteristics persistently over at least 12 months and in multiple relationships and settings. These characteristics reflect the individual's typical pattern of interpersonal and emotional functioning over this period and not just occasional occurrences in some situations. Thus, to assess the criteria for the specifier, multiple information sources are necessary. In addition to the individual's self-report, it is necessary to consider reports by others who have known the individual for extended periods of time (e.g., parents, teachers, coworkers, extended family members, peers).

Lack of remorse or guilt: Does not feel bad or guilty when he or she does something wrong (exclude remorse when expressed only when caught and/or facing punishment). The individual shows a general lack of concern about the negative consequences of his or her actions. For example, the individual is not remorseful after hurting someone or does not care about the consequences of breaking rules.

Callous—lack of empathy: Disregards and is unconcerned about the feelings of others. The individual is described as cold and uncaring. The person appears more concerned about the effects of his or her actions on himself or herself, rather than their effects on others, even when they result in substantial harm to others.

Unconcerned about performance: Does not show concern about poor/problematic performance at school, at work, or in other important activities. The individual does not put forth the effort necessary to perform well, even when expectations are clear, and typically blames others for his or her poor performance.

Shallow or deficient affect: Does not express feelings or show emotions to others, except in ways that seem shallow, insincere, or superficial (e.g., actions contradict the emotion displayed; can turn emotions "on" or "off' quickly) or when emotional expressions are used for gain (e.g., emotions displayed to manipulate or intimidate others).

DSM-5, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition the oldest studies investigating the comorbidity rate of the two disorders (Szatmari et al., 1989). As observed from the previous literature, the comorbidity of ADHD and CD is very common and almost one-third of the youth with ADHD have additional CD. This comorbidity rate is higher in boys compared to girls.

13.4 Mechanisms/Pathophysiology

There is plenty of research investigating the etiology of ADHD and CD, and various possible mechanisms and hypotheses have been established to explain the etiology of these disorders. However, similar to other psychiatric disorders, the etiopathogenesis of these disorders has not been fully understood so far. The etiology of ADHD or CD separately is not the subject of this section since this chapter focuses on the comorbidity of these disorders. Therefore, we will focus on the possible mechanism of comorbid conditions of ADHD and CD. The research focusing on the pathophysiology and developmental course of co-occurrence of ADHD and CD reveals that several possible genetic factors may play a role in the codevelopment of these two disorders. Since genetic issues on this subject will be discussed in upcoming sections of this subject, possible genetic mechanisms of co-occurrence of two disorders will not be elucidated in detail here. However, to make a comparison between the genetic and environmental factors, we will make a short discussion on this issue here. One study elucidated the relation between ADHD and CD from a genetic perspective and reported that participants with ADHD and coexisting CD show a higher relative risk to have ADHD and coexisting CD siblings (RRR = 4.9; 95%CI: 2.59–9.41) compared to ADHD-only participants (Christiansen et al., 2008). In addition, the same study reported that children with ADHD + CD demonstrate more severe ADHD symptoms than ADHD-only participants. This study indicates that there is a clear familiarity in the co-occurrence of ADHD and CD. Confirming this knowledge, Azeredo et al. concluded in their review that the onset and maintenance of ADHD and CD are rather associated with genetic factors than environmental ones though the importance of environmental factors is recognized (Azeredo et al., 2018). Similarly, Beauchaine et al. stated that coexistence among externalizing disorders results largely from genetic mechanisms, and a common latent factor accounts for much of the covariation among externalizing disorders such as ADHD, ODD, and CD. This latent factor is possibly a trait related to impulsivity which is expressed early in life as hyperactivity-impulsivity symptoms of ADHD (Beauchaine et al., 2010). Though this literature impresses that, rather than environmental factors, genetic influences possibly have a stronger influence on the codevelopment of ADHD and CD, several environmental factors were described as affecting the development of these disorders which will be elucidated in the upcoming sections of this chapter.

13.4.1 Development on the Basis of ADHD

Another hypothesis in the development of ADHD and comorbid CD is that CD develops on the basis of ADHD. According to this hypothesis, at the outset, a child with ADHD begins to show ODD symptoms, and then CD symptoms appear on the basis of ADHD and comorbid ODD. Several environmental or genetic factors influence this course. Despite DSM-5 suggesting that ADHD symptoms should arise before the age of 12, generally, the ADHD symptoms emerge earlier. Many participants demonstrate ADHD symptoms beginning from the preschool period and symptoms remain into adulthood. Similar to ADHD onset time, ODD symptoms typically develop by the age of 8, in contrast to CD which typically has a later age of onset. This temporal relationship simply indicates that there may be a relationship between these disorders in the developmental course of ODD and CD. The timing of their onset proposes that shared risk factors may play a role in the co-occurrence of ADHD, ODD, and CD among children who experience the mentioned comorbidity during childhood

(J Biederman et al., 2008). ADHD and CD could demonstrate similar temperamental characteristics; however, the later onset of CD proposes that correlates of ADHD could predispose to CD. Supporting this assumption, various research studies suggest that ADHD that persists into adolescence is related to a higher risk for the development of comorbid CD (Christiansen et al., 2008; Klein et al., 2012; Pardini & Fite, 2010). Therefore, this assumption suggests that the emergence of ADHD symptoms is preceded by CD, and this sequential nature of the two disorders suggests that ADHD may predispose to CD, or these disorders may share similar risk factors. Findings supporting the consecutive nature in the development of ADHD, ODD, and CD have been reported that ADHD could lead to CD, and ADHD symptoms predict increases in ODD and conduct problems over time (Pardini & Fite, 2010). In this trajectory, rather than inattentiveness, hyperactivity/impulsivity symptoms are suggested to be predictive for CD. In support of this viewpoint, Martin et al. (2006) found that CD shows a strong association with the impulsive form of ADHD, but exhibits a weaker association with the inattentive form (Martin et al., 2006).

Interesting findings about the relation between ADHD and CD were reported by the New York follow-up study, in which 207 children with ADHD between 6 and 12 years of age and a control group of children without ADHD were followed over a period of more than 30 years. No children with comorbid CD were included in the study. The researchers reported results indicating that a substantial proportion of ADHD children were diagnosed with conduct problems (32% vs. 8%) compared to controls at age 16–23 years (Mannuzza et al., 1989). Moreover, a higher proportion of children with ADHD had been arrested (39% vs. 20%) or convicted (28% vs. 11%) in their adolescence and early adulthood compared to controls. In addition, the presence of CD nearly completely accounted for criminal activities in these ADHD children. In the second investigation, 13–19 years after the baseline, 18% of the ADHD group proceeded to antisocial personality disorder compared to a very low rate in controls (2%) (Mannuzza et al., 1993). Similar to other studies, these findings indicate that children with ADHD are at high risk to develop CD. Adult studies also provide supportive findings on the developmental trajectory of ADHD and CD. Criminal adults generally have a developmental pathway that begins with severe impulsivity and hyperactivity in early toddlerhood, followed by ODD in preschool, early-onset CD in elementary school, substance use disorders (SUDs) in adolescence, and antisocial personality in adulthood (Loeber & Hay, 1997; Lynam, 1998). This pathway has been described as a heterotypic continuity since the behavioral phenotype varies considerably across development (Hinshaw et al., 1993). This trajectory may be affected by several environmental factors (i.e., peer groups, family environment, harsh discipline, problems in limit setting, insufficient socioeconomic conditions) which will be elucidated in the forthcoming sections of this chapter.

13.4.2 Early Onset Versus Late Onset CD

From the developmental perspective, early studies pointed out two types of developmental trajectories of criminal behaviors based on the findings obtained from long-term follow-up studies. The Dunedin longitudinal study followed 1037 infants at the age of 3 years up to 32 years and assessed the participants at different ages to obtain information about the development of psychiatric disorders (Odgers et al., 2007). This study revealed that two types of CD can be defined following different trajectories in the developmental course. In the first type which is called life-course-persistent offenders, the symptoms are exhibited beginning early in childhood accompanying high aggression levels and persistent violent offensive behaviors beginning from childhood throughout adolescence and adulthood. The second type of CD shows symptoms limited to puberty and late adolescence which is called "adolescent-limited offenders." The findings obtained from the Dunedin follow-up study indicate that participants with early onset differ from those with later onset. The early-onset participants exhibit more attentional problems, elevated impulsivity, poorer neuropsychological performance, lower IQ scores, more severe CU symptoms, more peer difficulties, and they are more likely to have an unfavorable family environment (Fairchild et al., 2019; Sharp, 2002). Researchers also reported poorer outcomes for the adulthood of the early-onset group, comprising poorer physical and mental health, poorer family and work-life functioning, higher rates of substance abuse, and committing violence compared to the adolescence-limited group (Moffitt et al., 2002; Odgers et al., 2007). By contrast, those with later onset are demonstrated to become delinquent as a result of social influences such as learning from peer groups or seeking social status through delinquent behaviors (Moffitt & Scott, 2009). The distinction between the early onset and limited to adolescence CD has been widely replicated by longitudinal studies of several cohorts from different countries (Moffitt, 2017). In their later follow-up studies, the Dunedin follow-up study researchers detected four different developmental subtypes of conduct problems: childhood-limited; childhood-onset/life-course persistent; adolescent-onset; and a low-trajectory type (Moffitt, 2017; Odgers et al., 2007). Based on this knowledge, the DSM classification system identified early-onset (i.e., beginning before the age of 10) and late-onset (i.e., beginning after the age of 10) types of CD (APA, 2013).

About the relationship between ADHD and CD in terms of the mentioned subtypes of CD, previous research showed that the prevalence of ADHD is the highest in the childhood-onset/life-course persistent type (38%), followed by the childhood-limited type (12%) and the adolescent-onset type (6%), and the lowest rate for the low-trajectory type (3%) (Moffitt, 2017; Odgers et al., 2007). These findings indicate that participants classified in childhood-onset/life-course persistent type of CD, which results in a poorer outcome compared to children with ADHD or conduct problems alone, have a higher probability of having an additional ADHD diagnosis, and this knowledge supports the aforementioned trajectory for the development of CD hypothesizing that CD develops on the basis of ADHD (Eskander, 2020; Moffitt, 1990). Several other studies report findings supporting this hypothesis. For example, compared to participants without ADHD, the age at first conviction was shown to be lower in young adult incarcerated offenders with ADHD (Rösler et al., 2004). Similarly, Satterfield et al. found that a large proportion of individuals with childhood ADHD committed their first crime prior to the age of 15 years (James H Satterfield et al., 2007).

However, despite the majority of the studies supporting that CD is a mediator between ADHD and criminal behaviors and there is a heterotypic continuity in the development of criminal and antisocial behaviors, a limited number of studies indicate that hyperkinetic symptoms have an independent influence on the occurrence of criminal behaviors in later life, claiming that rather than conduct problems, ADHD is an important risk factor in the development of criminal behaviors (Retz et al., 2021). Taylor et al. showed the effect of hyperactivity, which is independent of having a CD, on the occurrence of antisocial and violent behaviors in late adolescence (Taylor et al., 1996). Moreover, a longitudinal study conducted with 754 adoptees exhibited that the contribution of ADHD to disruptive behavior problems and arrests was independent of the presence of CD (Gunter et al., 2006). In line with these findings, Dalsgaard et al. reported that children with the ADHD combined subtype were twice as likely to have been convicted compared to children with the ADHD inattentive subtype even after controlling for the presence of CD and other potential confounding factors (Dalsgaard et al., 2013). Kuja-Halkola et al. have investigated the codevelopment of ADHD and externalizing behavior from childhood to adulthood using a birth cohort of 2600 twins, in which they assessed the probands at ages 8–9, 13–14, 16–17, and 19–20. Their findings suggested that externalizing traits in 8–9 years predicted ADHD-like traits at age 13–14, whereas the reverse association was not significant. On the contrary, ADHD-like traits in age 16–17 predicted externalizing traits in age 19–20 (Kuja-Halkola et al., 2015). The authors concluded that the results of the study obtain data in contrast to the belief that ADHD generally precedes externalizing behaviors. Based on this research, some researchers conclude that the treatment of ADHD is important and should be managed carefully and the clinicians should not wait for the CD symptoms to treat ADHD since the development of antisocial behaviors may be unrelated to conduct problems. On the other hand, some researchers point out that these disorders develop together independently from each other, and they show a high correlation since the two disorders mutually influence each other across childhood to adult life and become more strongly correlated over time (Kuja-Halkola et al., 2015). They emphasize that in this codevelopment process, the treatment of ADHD will not necessarily be sufficient to reduce the risks of CD, and CD should be treated apart from the ADHD treatment (Anita Thapar & Van Goozen, 2018).

Some researchers focused on the executive functions in the developmental course of ADHD and CD. According to their hypothesis, both ADHD and CD are related to impaired executive functioning and the deficit in executive functioning may be associated with stress reactivity of the participants with ADHD and CD. Too much or too little cortisol release can be harmful to brain functions, especially for executive functions, working memory impairments (Belanoff et al., 2001; Schoofs et al., 2008; Young et al., 1999). On the other hand, impaired stress reactivity which is related to aggressive symptoms may lead to decreased sensitivity to punishment that may prevent learning from the negative results of inappropriate behavior (Matthys et al., 2013; Van Goozen et al., 2007). Furthermore, lower activity of the autonomic nervous system (ANS), which is responsible for the regulation of arousal (as shown by lower heart rate and skin conductance reactivity) in antisocial or aggressive individuals causes an under arousal and consequently "fearlessness" condition by time (Lorber, 2004; Raine, 2002; Zuckerman, 1994). This hypothesis advocates that the combination of executive functioning and stress responsivity deficits may result in deficits in inference from social conditioning, especially from conditions including punishment. In addition, a structural stress responsivity deficit that causes a "fearless" condition promotes the deficits in reasoning from social conditions, which facilitates the course of conduct problems and antisocial features.

13.5 Etiopathogenesis

13.5.1 Environmental Risk Factors

Though several genetic vulnerabilities have been suggested in the development of CD, it has been well known that several environmental factors play an important role in the developmental course of CD (Fairchild et al., 2019). Some researchers claim that genetic factors have a substantial role in the development of CD rather than environmental factors (Azeredo et al., 2018), others indicate that rather than the CD itself, genetic factors are rather associated with ADHD-related features (i.e., impulsivity), and environmental factors promote the development of CD in the mentioned vulnerable individuals. Therefore, environmental factors have crucial roles in the development of CD (Retz et al., 2021). Numerous shared and nonshared environmental factors that may contribute to the development of CD have been reported in the previous literature. Obstetric and birth complications, malnutrition, exposure to heavy metals, and early-life maternal rejection are previously reported nonshared environmental factors associated with CD (Barker et al., 2012; Liu, 2011; Lukkari et al., 2012; Murray et al., 2016; Raine et al., 1997). These environmental factors are assumed to influence brain activity by causing a disruption in subcortical structures, neuronal loss, changes in neurotransmitter function, and neurotoxicity (Kim et al., 2015; Liu & Raine, 2006). Besides, harsh, coercive, and inconsistent discipline, maladaptive parenting, parent–child conflict, and contact with deviant peers are suggested relational factors associated with the development of CD. In addition, low socioeconomic status, poverty, exposure to community violence, previous history of parental crime, parental alcohol and drug problems, maternal depression, and family disorders are other acknowledged environmental factors (Fairchild et al., 2019; Jaffee et al., 2012; Johnson et al., 2017; Rowe et al., 2002).

Some of the research investigating environmental factors in the development of CD focused on the previously mentioned developmental trajectory of CD on the basis of ADHD. Several environmental factors are found to be effective in the development of CD in ADHD participants. Among these factors, parenting style and family features are the most consistent findings which have been demonstrated to be very important in the development of CD. About this issue, maltreatment, ineffective/coercive parenting style (for instance, shouting, corporal punishment, swearing, and threatening), harsh discipline, and inconsistent parental attitudes are previously reported familial factors that may conclude in CD in children with ADHD (Beauchaine et al., 2010; Fairchild et al., 2019). On contrary to coercive parenting styles, inadequate supervision and invasive and overprotective parenting are also related to CD development in ADHD participants (Rowe et al., 2002). Another important relational factor that has been demonstrated to affect this trajectory is peer relationship and exposure to the criminal environment. Exposure to deviant peers and living in a neighborhood of violence and criminality and alcohol use in adolescence are reported to be possible promoters of delinquency among impulsive boys (Dishion et al., 1999; Lynam et al., 2000; Meier et al., 2008; Viken et al., 1999). In addition to these factors, in a prospective follow-up study, low IQ and low socioeconomic status are reported to be unspecific risk factors in predicting antisocial behaviors in individuals with ADHD, and an elevated ratio of family members who have a history of criminal acts was detected in offenders with ADHD (J. H. Satterfield et al., 1982; James H Satterfield et al., 2007).

As mentioned above, previous literature depicts that exposure to accumulating environmental risk factors facilitates the progression of conduct behaviors among genetically vulnerable people (i.e., participants with high impulsivity). In line with this interpretation, a genome-wide association study indicates no additional genetic burden for children with ADHD coexisting with CD than those with ADHD alone (Anney et al., 2008). Despite some conflicting findings reported in the literature, if the mentioned association is correct, the emergence of CD among children with ADHD is substantially promoted by environmental factors (Zhou et al., 2008). Accordingly, impulsive children may likely develop CD in high-risk environments. For example, when reared in high socioeconomic status, low criminality neighborhoods, impulsive boys did not demonstrate an increased risk for delinquency compared to their non-impulsive peers (Lynam et al., 2000). Likewise, a positive parenting style is reported to have a possible protective role against the occurrence of CD among children with ADHD (Chronis et al., 2007). This literature represents that while a high-risk environment potentiates the development of conduct behaviors and delinquency in participants with ADHD, a protective environment can reduce the risks (Beauchaine et al., 2010).

The relation between family features and parenting styles, and the developmental course of CD in ADHD is not a unidirectional relationship. Contrary to the concept that conduct behaviors arise because of inappropriate parenting styles affecting vulnerable children, several studies indicate that, despite the inappropriate parenting in childhood contributes to the development of ODD and CD among children with ADHD (Deault, 2010; Johnston & Mash, 2001; Kashdan et al., 2004; Pfiffner et al., 2005), child disruptive behaviors also influence parenting styles (Burke et al., 2008). These findings suggest that ODD or CD symptoms may contribute to problematic family relationship patterns and comorbid disruptive behavior disorders may increase difficulties for parenting, resulting in a vicious cycle.

13.5.2 Genetic Factors

ADHD runs in families, with first-degree relatives of affected persons having a higher rate of the disorder (relative risk 4–5). The familial risk seems to be elevated among relatives who have both ADHD and CD (Joseph Biederman &

Faraone, 2005; Franke et al., 2012; Barbara Franke et al., 2018). This risk becomes further elevated when the proband has ADHD accompanied by CD (relative risk of around 9) (Stephen V. Faraone et al., 2000a). Moreover, a population-based twin study proposes stronger ADHD genetic loading in those who also have elevated levels of CD symptoms (Thapar et al., 2001). The comorbidity of the two disorders may be due to a general syndrome of disruptive behavior that the individuals exhibit and predispose to any of the disorders (T. S. Nadder et al., 2002). Researchers suggests that CD in those with ADHD is a marker of enriched ADHD familial/genetic loading which may be a subtype that is quantitatively rather than qualitatively different from other ADHD forms (Anita Thapar & Van Goozen, 2018). Three explanations exist for genetic influences: (a) ADHD behaviors cause to engage in disruptive or antisocial behaviors, showing a proclivity for ODD and CD; (b) rather than a phenotypic effect of ADHD on risk, the various phenotypes represent different manifestations of the same genetic responsibility; and (c) the link between ADHD, ODD, and CD emerges when children with ADHD encounter environmental hazards that do not stem from ADHD (T. S. Nadder et al., 2002). In actuality, there may be three separate genetic factors, at least in children: (a) affecting just responsible behaviors associated with hyperactivity; (b) influencing only the behavior disorder; (c) influencing both the hyperactivity and the behavior problem (Stephen V. Faraone & Larsson, 2019). The covariation between ADHD and CD is largely due to genetic factors and, to a lesser amount (19%), to nonshared environment effects (Tuvblad et al., 2009), with no meaningful data on shared environmental effects (Dick et al., 2005; Nadder et al., 2002; Tuvblad et al., 2009).

ADHD and CD frequently coexist, as is well documented. Shared genes have been linked to this connection in both twin and family studies (Faraone et al., 1997; Stephen V. Faraone et al., 2000b; Thapar et al., 2001). According to Hamshere et al., children who also have behavioral issues have a significant polygenic risk for ADHD (Hamshere et al., 2013). Family studies imply that ADHD with concomitant CD is a distinct subtype of disruptive disorder, with familial risk factors only partially overlapping with those with pure ADHD (Stephen V. Faraone & Larsson, 2019; Jensen et al., 1997). It has been proposed that ADHD with comorbid CD may be a more severe form of ADHD rather than two different disorders and that the co-occurrence of ADHD and CD symptoms is explained by a highly heritable externalizing behavior component (Dick et al., 2005; Nadder et al., 2002; Thapar et al., 2001; Tuvblad et al., 2009).

ADHD molecular genetic studies have only recently begun to yield individual, significantly associated, risk loci, but composite measures of even subthreshold risk alleles, known as polygenic risk scores, which are derived from a 'discovery' case-control sample, distinguish ADHD cases from controls in independent samples (Hamshere et al., 2013; Anita Thapar & Van Goozen, 2018). In keeping with the view that CD indexes higher genetic loading in those with ADHD, one study found that ADHD polygenic risk scores predicted a diagnosis of CD within an independent ADHD sample (Hamshere et al., 2013; Smoller et al., 2013). Much research interest focused on a DNA variant within the gene encoding the enzyme COMT (catechol- O-methyltransferase) due to the fact that COMT is the main pathway by which dopamine is broken down in the prefrontal cortex and the val158met variant impacts enzymatic activity. Although meta-analyses of ADHD case-control studies show that COMT val158met is not associated with ADHD itself (Lee & Song, 2018), several studies and a meta-analysis have observed an association between COMT val158met and CD, CD symptoms, and adult criminality in those with ADHD but not with CD alone (Caspi et al., 2008). Caspi et al. could demonstrate that, in three separate populations of ADHD cases, the COMT val/met polymorphism at codon 158 is linked to more aggressive behavior and a higher probability of being convicted of a crime. This form of ADHD may also raise the risk for eventual delinquent behavior because the intensity of ADHD psychopathology and its pervasiveness are thought to predict persistence and poor outcomes (Anita Thapar et al., 2006). This suggests that COMT activity moderates the manifestation or subsequent development of CD in those with ADHD, although candidate gene study findings are now regarded with caution unless they are robust to genome-wide significance.

The identification of inferred and directly assessed genetic contributions to CD in ADHD leads to the next question: how do genetic risks impact CD in those with ADHD (Anita Thapar & Van Goozen, 2018)? A meta-analysis of imaging studies in non-ADHD populations has found evidence of COMT val158met association with performance on paradigms assessing executive function (favoring met allele) and affective paradigms (favoring high-activity val allele) (Mier et al., 2010). Thus, COMT val158met could have risk effects on CD in those with ADHD via impacts on (a) executive functioning and (b) affective response (Mier et al., 2010). In a large longitudinal UK population cohort (Avon Longitudinal Study of Parents and Children [ALSPAC]), Langley et al. observed that COMT val158met predicted CD symptoms in those with higher levels of ADHD, performance on a task measure of executive function, and a questionnaire measure of emotional/ social function (Langley et al., 2010). The association between COMT val158met and CD symptoms (in those with higher ADHD) was partially mediated by emotional/ social function but not by executive function (Langley et al., 2010). A more recent study based on a clinically referred ADHD sample also found that affective processing rather than executive functioning mediated the link with CD (Van Goozen et al., 2016).

According to most research, the overwhelming variance in ADHD and CD is explained by unique, non-shared genetic and environmental factors, with 21% of the variance in boys and 7% in girls attributable to shared genetic influences for both ADHD and CD (Kerekes et al., 2014; Tuvblad et al., 2009). Using the information on the symptoms of ADHD and ODD/CD gathered from a brief telephone interview, Nadder et al. investigated the genetic and environmental relationships in a twin sample and found that the correlation between the two symptoms was more strongly influenced by genetic factors than by factors specific to a child's environment (0.50 vs. 0.39) (Teresa S Nadder et al., 1998). When teacher assessments were included in a 19-month follow-up study, the authors discovered significantly stronger (0.64 to 0.82) genetic correlations between the two symptoms. Because teacher ratings were more reliable than maternal ratings in the follow-up, it is likely that the genetic associations were larger (T. S. Nadder et al., 2002). The face-to-face interview was then undertaken in two more investigations using twin child samples with a limited age range (Dick et al., 2005; Tuvblad et al., 2009). The twin investigations confirmed the significance of associated genetic risk for the coexistence of ADHD and CD symptoms by detecting genetic correlations larger than child-specific or shared environmental correlations, as in other studies (Dick et al., 2005; Tuvblad et al., 2009). While the majority of twin research identified high genetic overlap between ADHD and CD, one study discovered a large shared environmental overlap with relatively moderate genetic impact. Burt et al. examined symptom counts for ADHD and CD collected from interviews with 11-year-old twins and their mothers as part of the Minnesota Twin Family study (Burt et al., 2001). The authors found that a single shared environmental factor contributed the most to the covariation between the two disorders (Burt et al., 2001). Except for the Burt et al. study, the majority of twin investigations of ADHD and CD in children and adolescents indicated shared genetic liability as a substantial causative risk factor leading to the comorbidity of CD and ADHD. Genetic correlations were typically 0.4–1, whereas shared environmental and child-specific environmental correlations were negligible or weak (Hur, 2015).

In conclusion, even if there is no complete agreement among studies, the association between CD and ADHD can be explained by both genetic factors and shared as well as nonshared environmental impacts. To better elucidate the reason of these co-occurrences, future studies are required to obtain a stronger disentanglement of the relative contribution of genetic and environmental variables.

13.5.3 Gene–Environment Interactions

The nature versus nurture issue has been reframed by the study of gene–environment interactions (GxE), which also offers a model for how the interaction of the two factors can affect development. Environmental stressors and inherited vulnerabilities work together to cause a malfunction in stress–diathesis–type interactions, which strengthen genetic effects in high-risk contexts (Pennington et al., 2009). Interactions can also follow the so-called bioecological paradigm, in which harmful or protective genetic influences are expressed in enriched circumstances, resulting in higher heritability in low-risk circumstances (Friend et al., 2008).

Epigenetic programming is affected by both an individual's genetic structure and environment, albeit the role of the environment in the etiology of the condition appears to be less than that of genetic factors (approximately 22% of ADHD variance explained by environmental factors) (Joseph Biederman & Faraone, 2005; Nikolas & Burt, 2010). The notion of GxE interaction is consistent with epidemiologic studies showing a link between ADHD and environmental adversity. These risk factors include prenatal and perinatal risk factors (maternal psychosocial stress, smoking during pregnancy, prematurity, and low birth weight), environmental toxins (organophosphates and lead), unfavorable psychosocial conditions (severe early-childhood deprivation and parental mental health problems) and nutritional factors (Stephen V. Faraone et al., 2015). GxE interactions are likely to exaggerate the heritability estimates for ADHD based on twin studies (Purcell, 2002), which may also partially explain some contradictory findings of genetic linkage. As a result, numerous studies have shown that genetic variations can affect how environmental risk factors for ADHD affect an individual (Barbara Franke et al., 2018). For example, interactions have been found between DRD4 and prenatal smoking exposure (Pluess et al., 2009), SLC6A3/DAT1 and maternal alcohol use during pregnancy (Brookes et al., 2006), institutional deprivation (Kumsta et al., 2010), psychosocial adversity (Laucht et al., 2007), MAOA and unfavorable parenting behavior (Li & Lee, 2012), and ADGRL3 / LPHN3 and maternal stress during pregnancy (Choudhry et al., 2012).

The majority of GxE studies on ADHD have emphasized prenatal exposure to maternal risk factors (Rutter, 2007). Prior studies have paid less emphasis to the postnatal social environment. However, the social environment may serve as the main risk factor for the emergence of ADHD. The best evidence for this potential causal role comes from the detection of developmental outcomes linked to institutional deprivation (Kreppner et al., 2001). These results repeatedly show that children raised in impoverished institutional care had higher rates of inattention/ hyperactivity in both childhood and early adolescence (Stevens et al., 2008). The relation between early deprivation and later ADHD symptoms may be mediated by dysregulated stress reactivity. Children with symptoms of inattentive-type ADHD have a dysregulated cortisol response to stress (Randazzo et al., 2008). The hypothalamic–pituitary–adrenal (HPA) axis is principally responsible for these responses. It seems that dysregulation of the HPA axis involving a dysfunctional behavioral inhibition system, which is linked to poor response inhibition, one of the fundamental deficits in ADHD.

Children who are homozygous for the DAT1 10-repeat allele are more likely to acquire symptoms of ADHD when exposed to unfavorable psychosocial adversity (Laucht et al., 2007). Maternal insensitivity has been demonstrated to predict externalizing disorders in preschoolers only when the children carry the DRD4 seven-repeat allele (Bakermans-Kranenburg & Van Ijzendoorn, 2006), while parental warmth protects against these disorders only when this allele is absent (Propper et al., 2007). The 5HTTLPR polymorphisms also seem to raise the risk for externalizing behaviors through interacting with social adversity. The short allele interacts with an unfavorable childhood environment and is linked to substance abuse in the context of inappropriate parenting to predict the distal risk for violence in young adults (Gerra et al., 2007; Reif et al., 2007).

The genotype of DRD4 in the child can also affect how well parenting education works (Bakermans-Kranenburg et al., 2008). A study that employed the video-feedback intervention to support appropriate parenting and sensitive discipline (VIPP-SD) to improve parental sensitivity discovered that VIPP-SD was successful in reducing externalizing behavior in children who had the DRD4 seven-repeat allele. Children who had the DRD4 seven-repeat allele and whose parents used positive discipline more frequently were most affected by VIPP-SD. The intervention had no effect when the children did not have the seven-repeat polymorphism. According to this study, the moderating effect of the DRD4 seven-repeat allele, with an effect size of 0.47, could account for 4% of the variance. This study reveals how a child's response to environmental enrichment can be affected by genes (Bakermans-Kranenburg et al., 2008).

The DRD4 seven-repeat polymorphism is linked not just to ADHD but also to motivational and reward systems. A "reward deficiency syndrome" is linked to this genotype, according to some research studies (Seeger et al., 2004). The seven-repeat allele may make children less responsive to reinforcement or rewards. Thus, it may be necessary for their parents to assist them in providing additional cues so that they can predict rewards and consequences of behavior (Seeger et al., 2004).

13.5.4 Brain Mechanisms

13.5.4.1 Structural Neuroimaging

In a systemic review and meta-analysis, Noordermeer et al. found lower total grey matter volumes in the ADHD and coexisting ODD/CD group compared to the control group. They also demonstrated abnormalities in the left amygdala in the ADHD and coexisting CD group. In addition, they reported abnormal volumes in the ADHD and coexisting CD group that were not seen in the ODD/CD alone group. This is explained by the fact that these abnormal volumes indicate the presence of coexisting ADHD rather than ODD/CD. The smaller volume structures shown in this review are the temporal lobe and cerebellum. In this study, the authors also showed a relationship between the amygdala, insula, and temporal cortex and ODD/CD symptoms (Noordermeer et al., 2016).

13.5.4.2 Functional Neuroimaging

Executive functions (EF) are cognitive processes including planning, decision-making, selective attention, set-shifting and set maintenance, working memory, interference control, motor inhibition, integration across space and time, and temporal foresight that are required for goal-directed behaviors (Stuss & Alexander, 2000). In the field of EF, two distinct EF were defined as hot and cool EF (Zelazo & Carlson, 2012). Hot EF is characterized by affective and motivational cognitive processing, including affective decision-making, reinforcement learning, and emotional processing (Blair & Lee, 2013; Zelazo & Carlson, 2012). The amygdala, insula, anterior cingulate cortex, and orbitofrontal cortex are important brain areas for hot EF (Noordermeer et al., 2016; Prencipe et al., 2011; Rubia, 2011). Cool EF, on the other hand, refers to goal-directed and problem-solving behaviors, as well as self-regulation that does not involve motivational or affective components. The term "cool EF" refers to a range of abilities, including inhibition, working memory, planning, flexibility, and the capacity to come up with original solutions to issues (Diamond, 2013; Noordermeer et al., 2016; Stuss & Alexander, 2000). Dorsolateral prefrontal cortex and cerebellum are believed to be key brain regions for cool EF (Noordermeer et al., 2016; Prencipe et al., 2011; Rubia, 2011).

Noordermeer et al. identified 10 studies examining hot EF in ODD/CD and ODD/CD and coexisting ADHD groups and reported abnormal function of the striatum, which includes the caudate, putamen, and amygdala. Furthermore, functional abnormalities in the parietal cortex were detected in ODD/CD-mixed groups but not in ODD/CD-only groups. This could mean that concomitant ADHD rather than ODD/CD is the cause of the aberrant activity in the parietal cortex (Noordermeer et al., 2016). In five of the articles reviewed by Noordermeer et al., the relationships between ODD/CD-related symptoms and activities of specific structures were also examined. All five research found a negative correlation between amygdala activity and ODD/CD-associated symptoms (i.e., a smaller volume related to greater ODD/CD symptoms). In addition, two of the five studies—one of which examined an ODD/CD-only population and the other an ODD/CD-mixed sample—found negative correlations between the left and right anterior cingulate cortex activity and symptoms related to ODD/CD.

In the article published by Noordermeer et al., no study was found to compare the ADHD +ODD/CD group with the ODD/CD-only group and control group with respect to Cool EF. They identified only five studies comparing ODD/CD with the control group for Cool EF. The authors found that ODD/CD-only groups had reduced activation in the precuneus. They also found that ODD/CD-only groups had decreased activity in the right anterior cingulate, right insula, and right posterior cingulate cortex. In their systematic review and meta-analysis, two studies examined the relationships between the activity of particular brain regions and ODD/CD-related symptoms. One of the studies found a negative relation between the dorsolateral prefrontal cortex and these symptoms, while the other found none. Four studies examined the disorder specificity of the anomalies for ODD/CD in comparison to ADHD-only in terms of specificity. In one of these four studies, abnormal activity was found to be specific for ODD/CD-only in the insula, anterior cingulate cortex, cerebellum, and hippocampus, while in another study, lower activity was found to be specific for ODD/CD-only in the left parietotemporal cluster and right parietal lobe (Noordermeer et al., 2016).

13.5.5 Stress, ADHD, and CD

Researchers investigating the link between stress and ADHD showed that certain patterns of reactivity may be related to an elevation in the severity of the disorder or an elevation in behavioral difficulties. However, there is not enough evidence to draw firm judgments regarding the nature of the link between a certain symptom or behavior and the stress response. Only a small percentage of studies on cortisol levels in ADHD participants have taken into account coexisting behavioral issues, and these studies have produced mixed findings (Blomqvist et al., 2007). Some studies have reported reduced cortisol levels in children with ADHD and comorbid ODD/CD, but not in those with ADHD alone (Çakaloz et al., 2005; Freitag et al., 2009). However, another study found no influence of comorbid ODD/CD on cortisol levels in an ADHD population (Isaksson et al., 2012). In a similar vein, a recent study found no changes in baseline cortisol levels between patients with ADHD alone and patients with ADHD coexisting with CD in male adolescents (Northover et al., 2016). Regardless of the presence of ADHD, there have been research that have focused on the relationship between cortisol and CD. In general, these research have shown that people with CD have lower cortisol levels, and a recent meta-analysis of 82 studies using samples from children and adolescents discovered a significant but weak ($d = 0.10$) link between low cortisol levels and antisocial behaviors (Alink et al., 2008). Işık and Bilgiç, who are also the authors of this section, examined whether there was a difference between the groups in circulating morning cortisol levels in the ADHD, ADHD+CD, and control groups, and they could not detect any difference between the groups in terms of morning cortisol levels (Işık et al., 2018).

Although research studies evaluating cortisol levels have included a stressor, there have been few studies evaluating sympathetic-adrenomedullary (SAM) system activity in cases with ADHD or in those with ODD/CD. According to studies on reward response, having both ADHD and CD or ODD appears to be related with lower SAM activation compared to peers who solely have ADHD or are typically developing. These research discovered greater baseline pre-ejection period (PEP) reactivity, decreased PEP responsiveness to reward, and a link between lower skin conductance measurements and elevated impulsivity and externalizing issues (Beauchaine et al., 2001, 2007; Crowell et al., 2006). The findings of one study were slightly different, showing that children with ADHD had reduced heart rate reactivity to stress but that people with ADHD coexisting with CD had increased heart rate compared to children with ADHD alone (Van Lang et al., 2007). Another study that included a very mild possibly stress-inducing noise stimulus showed that children with ADHD coexisting with CD had lower skin conductance levels (SCL) than peers with only ADHD and a control group (Herpertz et al., 2001).

The true association between ADHD, coexisting CD, and the stress response may be better understood by studying the HPA axis activity in response to stress. In one study on the HPA axis, the researchers evaluated the cortisol response to stress in children between the ages of 7 and 12 who had DBD alone, DBD and comorbid ADHD, ADHD alone, and previously gathered data from children with normal controls. The findings of this study revealed that ADHD alone does not explain a reduced stress response, as the group with ADHD-only displayed cortisol levels comparable to the control group. Cortisol release in response to stress in those diagnosed with both ADHD and DBD appeared similar to that of DBD-only participants, with decreasing levels following stress (Snoek et al., 2004).

13.5.6 Temperament

Temperament has been attributed to the etiology of developmental psychopathology, with early-appearing characteristics proving to be reliable predictors (Rothbart & Bates, 1998). Temperament is commonly defined as constitutionally based individual variances in reactivity and self-regulation in the domains of affect, activity, and attention (Rothbart & Bates, 1998). While temperament traits are not pathological in and of themselves, excessive deviations or certain combinations of traits can contribute to pathological behaviors. This strategy has been studied in various research, which used a temperament model with three dimensions that were derived empirically: *negative affect*, such as tendencies to react with anger, frustration, or fear; *positive affect or surgency* which includes overall activity, expression of happiness, and interest in novelty; and *effortful control* which is related to self-regulation and the control of action (Martel et al., 2009; Martel & Nigg, 2006; Nigg, 2006). The latter category exhibits significant overlap with the idea of executive function. The multiple pathway model of disorder development proposed by Nigg et al. is based on the assumption that certain temperaments early in life give rise to disordered behaviors (e.g., ADHD and comorbid disorders) (Nigg, 2006; Nigg et al., 2004). In the first of this pathway, Nigg et al. hypothesize that early negative temperament (i.e., anger) leads to later problems with regulation. This factor may subsequently contribute to ADHD-combined type and concomitant DBD, as well as mild executive dysfunction, notably in executive attention. According to a second proposed pathway, early disruption in regulatory skills can result in both fundamental deficiencies in executive functioning and potential DBD comorbidity. The third pathway suggested to cause ADHD and coexisting CD posits a developmental trajectory focused on low arousal or withdrawal-related behaviors linked with subsequent serious behavioral problems as well as low physiological arousal/diminished anxiety (Nigg, 2006; Nigg et al., 2004).

Children with behavioral disorders frequently exhibit negative temperamental traits and struggle to control their anger, aggression, and other unpleasant emotions; in fact, emotion regulation issues are particularly linked to aggressive symptoms in children with ADHD (Frick & Morris, 2004; Steinberg & Drabick, 2015). Additionally, children with ADHD who exhibit negative affect and reactivity frequently evoke harsher parenting approaches, aggravating children's oppositional and behavioral issues (August et al., 1999; Barkley, 1997; Chronis et al., 2007; Steinberg & Drabick, 2015). Given that ODD is linked to negative emotionality (Martel & Nigg, 2006), it stands to reason that children with ADHD who also struggle with emotion regulation, such as being prone to negative, angry, or aggressive behaviors, may experience symptoms of ODD. This is especially true when parents use strict, inconsistent, or unsupportive parenting techniques (August et al., 1999; Chronis et al., 2007). Early temperamental characteristics, particularly effortful control and activity level, were found to potentially predict later ADHD in a population sample (Einziger et al., 2018). In a sample of children with ADHD, Karalunas et al. identified three temperament types: one with normal emotional functioning; one with high surgency, characterized by a high level of approach-motivated behaviors and activity; and one with a high level of negative ("irritable") affect, with the latter displaying the strongest, albeit only moderate stability over 2 years (Karalunas et al., 2014, 2019). It was concluded that irritability, a trait of the ADHD subgroup with predictive validity for a poor outcome, cannot be attributed to comorbidity with ODD or CD (Karalunas et al., 2014, 2019). There is evidence that psychiatric disorders other than ADHD are also connected to temperamental traits. For instance, disruptive behavior disorders, such as ODD, which frequently co-occur with ADHD, are linked to temperamental negative affectivity (Frick & Morris, 2004; Martel et al., 2012; Martel & Nigg, 2006; Nigg et al., 2004). In conclusion, co-occurring emotion regulation deficiencies such as poor reactive control, negative emotionality, high irritability, low agreeableness, and high approach tendencies may play a role in the emergence of co-occurring ODD in children with ADHD (Martel, 2009). As a result, these children are predicted to have emotion regulation profiles defined by under regulation. Though it hasn't been studied as much in terms of emotion regulation dysfunction, the CD is likewise characterized by decreased levels of emotion regulation (Cappadocia et al., 2009). There is currently no research that can tell us which temperamental characteristics predict CD in people with ADHD (Anita Thapar & Van Goozen, 2018).

Temperament, according to Cloninger's concept, refers to individual biological profiles and patterns of response to external stimuli that stay relatively stable throughout life and are heavily influenced by genes (Cloninger et al., 1993). Cloninger identifies four etiologically separate characteristics in his psychobiological model: novelty seeking, harm avoidance, reward dependence, and persistence (Cloninger et al., 1993). The question of whether and how much certain temperamental traits may be linked to ADHD has been the subject of numerous studies. Marwood et al. investigated the role of genetic and environmental factors in the correlation of ADHD with Cloninger's temperament characteristics using a large population-based twin sample (Merwood et al., 2013). The key findings revealed that inattention and hyperactivity/impulsivity were both related to novelty seeking, a dimension that suggests impulsivity and irritability, with shared genetic impacts across these variables. Additionally, there were different relationships between harm avoidance and persistence and the two aspects of ADHD: harm avoidance was specifically linked to genetic influences on inattention, whereas persistence had a positive relationship with hyperactivity/impulsivity and a negative relationship with inattention. These findings imply that novelty seeking may reflect a major aspect of combined presentation ADHD, as well as the possibility that the two ADHD dimensions may be characterized by distinctive temperamental profiles (Merwood et al., 2013). Since novelty seeking seems to be a distinct trait of ADHD, interventions should place an emphasis on positive traits connected to this temperamental dimension, like curiosity and the desire to explore the uncharted, enhancing strengths rather than deficits of those with ADHD (Merwood et al., 2013).

In conclusion, earlier research revealed that the presence of ADHD in children is linked to high levels of fine-grained temperamental traits linked to negative emotional reactivity, such as anger and sadness (Einziger et al., 2018; Foley et al., 2008; Martel & Nigg, 2006). ADHD symptoms are also linked to highly engaged approach systems, as seen in high surgency, activity level, impulsivity, approach-sociability, and novelty seeking (Donfrancesco et al., 2015; Einziger et al., 2018; Foley et al., 2008; Martel et al., 2014; Martel & Nigg, 2006). Low levels of effortful self-regulation, such as effortful control, conscientiousness, and fine-grained aspects, like attentional/behavioral control and persistence, also pose risk concerning ADHD (Donfrancesco et al., 2015; Forbes et al., 2017; Martel et al., 2014; Martel & Nigg, 2006). ODD and CD are linked to temperamental traits like high novelty seeking, high emotionality/low persistence, and disinhibition (Hirshfeld-Becker et al., 2002; Prior et al., 2001; Rettew et al., 2004). High novelty seeking and low harm avoidance are also linked to CD (Hirshfeld-Becker et al., 2002; Martel et al., 2012; Schmeck & Poustka, 2001).

In addition to the child's temperament, parental temperament characteristics may also be important in the development of oppositional defiant and CD diagnoses in ADHD cases. In this context, to our knowledge, there are two studies in the literature examining parental temperament characteristics that may lead to the development of ODD and CD in ADHD cases (Bilgiç et al., 2018, 2021). In the first of these studies, according to parent-rated behavioral disorder scales, maternal irritable and paternal cyclothymic temperaments had an association with ODD scores, and maternal depressive temperament had an association with CD scores. Regarding teacher-rated behavioral disorder scales, maternal anxious temperament had an association with ODD scores, and paternal cyclothymic and maternal depressive temperaments had associations with CD scores (Bilgiç et al., 2018). In another study, a positive relationship was found between maternal anxious and irritable temperament and ODD scores, and between maternal irritable and paternal cyclothymic and hyperthymic temperament and DB scores (Bilgiç et al., 2021). Therefore, in ADHD+CD cases, it should be considered that the temperament of the parent as well as the child is important.

13.6 Diagnosis

Both the DSM-5 and ICD-11 have similar descriptions for the defining features of CD such as repetitive and persistent patterns of behavior in which the basic rights of others or major age-appropriate norms or rules are violated, as indicated by aggression to people or animals, destruction of property, deceitfulness or theft, or serious rule violations (APA, 2013; Harrison et al., 2021). Because these definitions comprise heterogeneous groups of individuals, both the classification systems include some subtypes or specifiers. For instance, the disorder could be divided into two subtypes according to the age of onset of symptoms as the childhood-onset subtype (at least one symptom prior to 10 years of age) and the adolescent-onset subtype (all symptoms emerge after 10 years of age). This division was based on studies that demonstrated the more severe and chronic behavior problems and the stronger neurodevelopmental influences such as CU traits, impulsivity, and low intelligence in childhood-onset cases (Fairchild et al., 2019).

The DSM-5 also has a specifier according to the number and severity of symptoms as mild, moderate, and severe manifestations of CD (APA, 2013). Additionally, both the DSM-5 and ICD-11 have the LPE specifier including the lack of remorse or guilt, callous—lack of empathy, unconcerned about performance, and shallow or deficient affect (APA, 2013; Harrison et al., 2021). The only difference between these classification systems in the definition of LPE is that the ICD-11 also includes an additional symptom which is the indifference to punishment (Harrison et al., 2021). Individuals who have CU traits show more severe and ongoing behavioral problems and poor treatment responses. Because cases with CD and CU traits or cases with severe symptoms seem to have at least partly distinct etiopathogenesis from their counterparts with CD only or mild manifestations, it is important to identify these subtypes in the diagnosis process of CD (Frick, 2012).

Children with ADHD who have comorbid CD often exhibit more severe symptoms and more coexisting psychiatric conditions such as substance misuse, learning disorder, interpersonal relationship problems, and academic or occupational problems compared to children who do not have the comorbid CD (Fairchild et al., 2019). Establishing these coexisting conditions is very crucial to developing an appropriate treatment plan for target symptoms. Thus, children with ADHD who have comorbid CD should also be evaluated elaborately with respect to the existence of other coexisting conditions.

For an appropriate diagnosis, structured or semistructured diagnostic interviews such as Kiddie-Schedule for Affective Disorders and Schizophrenia (K-SADS), Diagnostic Interview for Children and Adolescents (DICA), or Diagnostic Interview Schedule for Children (DISC) may be performed with the parents, other adults who observe the child in different settings and child (Kaufman et al., 1997; Shaffer et al., 2004; Welner et al., 1987). To assess the presence of CU traits, behavior rating scales such as the Inventory of Callous-Unemotional traits (ICU) and Child Problematic Traits Inventory (CPTI) may be beneficial (Colins et al., 2014; Kimonis et al., 2008).

13.6.1 Critical Issues in Diagnosis

The diagnostic assessment of youth with CD coexisting with ADHD should include the determination of the level of aggression and potential risk of harmful behaviors to other persons. The assessment of co-occurring psychiatric problems such as alcohol or drug abuse, depression, anxiety disorders, suicidality, and autistic features is also important. Youth with CU traits appear to show more enduring and severe aggression and behavior problems and poorer responses to treatment compared with those without CU traits (Frick et al., 2014). Additionally, there is some evidence regarding the existence of distinct causal processes and developmental pathways between youth with CD and CU traits with low levels of anxiety and those with high levels of anxiety. Therefore, the evaluation of anxiety levels in these cases could be informative. By considering these factors, clinicians should address the intensity of required treatment and maintain other individuals' safety (Cecil et al., 2018).

While maltreatment and malnutrition risks are elevated in individuals with CD coexisting with ADHD, a medical examination may be indicated in certain youth. Social and educational difficulties and legal issues should also be taken into account. The evaluation of the common risk factors for the development of CD may be useful for the establishment of a wise treatment plan, including harsh and inconsistent parenting styles, emotion regulation problems, and elevated CU traits. Evaluating the age of onset of the child's behavior problems and whether the child shows problematic behaviors across multiple relationships and settings are also crucial for a comprehensive and individualized treatment approach (Fairchild et al., 2019; Frick, 2012).

13.7 Screening

While treatment is more effective early in development, screening for CD symptoms is crucial for identifying children at risk for the development of CD (Frick, 2012). Parent- or teacher-report rating scales are the most common and useful method for screening for nonnormative behavioral problems in young children that can lead to the development of CD. A convenient screening scale should identify nonnormative behavioral problems when they just begin to cause impairment, but before the child meets the full criteria for CD, and behavioral problems are still milder and treatable (Fairchild et al., 2019).

Young children with ADHD who show behavioral problems outside the home are at an elevated risk of later CD and children who have problems at school typically also have problems at home (Frick & Nigg, 2012). Therefore, screening at school with a teacher-rated scale in early life seems to be very crucial. For instance, the Teacher Observation of Childhood Adaptation-Revised (TOCA-R) which is a teacher-delivered questionnaire that includes 14 items seems to be appropriate for screening conduct problems in kindergarten students (Werthamer-Larsson et al., 1991). This scale was used in the Fast Track (FT) intervention which was a multimodal preventive intervention addressing the development of antisocial behaviors across 10 years of childhood (Godwin et al., 2020). In this study, children who have elevated scores in the TOCA-R were also screened for conduct problems at home by parents using 24 items on the Child Behavior Checklist (Achenbach & Rescorla, 2001).

The Sutter-Eyberg Student Behavior Inventory-Revised (SESBI-R) and Eyberg Child Behavior Inventory (ECBI) are comprehensive screening tools for CD symptoms at home and school, respectively (Eyberg & Pincus, 1999). These scales include 36 different items, and normative cut-off values were established for children and adolescents aged between 2 years and 16 years. The Strengths and Difficulties Questionnaire (SDQ) is a five-item conduct problems scale and is also an effective screening tool for CD (Goodman et al., 2003).

13.8 Prevention

Parenting interventions based on social learning principles are a first-line and effective prevention approach for CD in children with ADHD, especially in early childhood. In an effective prevention program, a variety of risk factors such as peer rejection, deviant peer involvement, difficulty in school, inappropriate parental discipline approaches, and lack of parental monitoring were targeted based on developmental theory. Clinicians should also focus on parenting behaviors that may affect emotion regulation ability because it is crucial for the development of important skills and may buffer children against potential risks. While the majority of cases who show severe trajectories of antisocial behavior often begin early in childhood, the effective treatments for disruptive behaviors in these years are key for the prevention of CD (Fairchild et al., 2019).

Three different programs could be used for the prevention of CD. Primary or universal programs aimed to prevent the development of CD in the general population; selective programs aimed to prevent the development of the disorder in children who have individual or contextual risk factors; and indicated programs aimed to prevent the development of the disorder in children who show subclinical symptoms of CD. According to systematic reviews and meta-analyses, primary and selective prevention programs for CD symptoms had effect sizes ranging from zero to small, whereas indicated prevention programs had effect sizes ranging from small to medium (De Vries et al., 2015; Hendriks et al., 2018).

Given that CD is related to remarkable and lifelong personal and societal costs, more research and funding are necessary for the prevention of this disorder in children with ADHD. Studies that would identify modifiable environmental and individual risk factors for the development of CD could support the preventive efforts. A key issue seems to convince policymakers to have a long-term perspective regarding the prevention of CD symptoms.

13.9 Management

13.9.1 Behavioral Interventions

Management of CD in children with ADHD must be established based on developmental models according to the child’s age (Michelson et al., 2013). Improvement could usually occur through behavioral interventions that mainly target parents’ or primary caregivers’ attitudes, the child’s home and school context, and peer group. It is aimed to reduce the core symptoms of CD and coexisting psychiatric symptoms, improve emotion regulation abilities and social skills, enhance educational and occupational achievements, and control and reduce criminal behaviors (Fairchild et al., 2019).

13.9.1.1 Behavioral Interventions During Early to Middle Childhood

Evidence-based guidelines and meta-analyses for the treatment of CD in the preschool and primary school years recommend behavioral parent training based on social learning theory as a first-line approach (Michelson et al., 2013). Manualized parenting training programs have been detected to be effective in at least two randomized controlled trials including the Incredible Years Program, the Parent Management Training Oregon Model, and the Triple P–Positive Parenting Program (Fairchild et al., 2019; Sanders, 2012; Webster-Stratton & Reid, 2003). Given that these interventions are more beneficial early in childhood and early-onset CD show more detrimental outcomes (Comer et al., 2013), the offering of early intervention parenting programs to parents of young children with ADHD who show CD symptoms seems to be reasonable.

In general, these interventions include several important components, such as positive reinforcement of desirable child behavior and increasing parental warmth followed by providing effective instructions to children and setting limits on unfavorable child behaviors with a consistent and nonaggressive manner. Parental skills are developed via in-session modeling of desirable parental attitudes by therapists, role-play, and homework. The differences between programs are not prominent and include supplementary components, such as strategies to teach problem-solving skills and address other psychosocial stressors within the family (Fairchild et al., 2019).

Cognitive-behavioral skills training targets to improve the social-cognitive processes, social-problem solving, and self-regulation abilities in children, and this approach could be more effective with increasing age. For instance, problem-solving skills training that includes 25 weekly group training sessions with children 7–13 years of age aimed to enhance the practice of skills with peers. To increase the efficacy for children with CD who show CU traits, emotion processing training with children and their parents is also recommended (Dadds et al., 2012). Children-focused cognitive-behavioral interventions have had very small effect sizes compared to parent training interventions in early to late childhood (McCart & Sheidow, 2016). Thus, cognitive-behavioral skills training should be applied in conjunction with parents' training. Nonetheless, multimodal interventions comprising both child-focused and parent-focused components are recommended (NICE Clinical Guidelines, 2017).

A systematic review showed that, for children 8 years of age and younger, the most common studied interventions are group parent training treatment programs, with an effect size of 0.50–0.83 (Scotto Rosato et al., 2012). Multicomponent treatment approaches comprising a combination of improving positive parenting, classroom management for teachers, and interpersonal and social skills for children are other commonly studied interventions, with an effect size of 0.23–0.38 (Scotto Rosato et al., 2012).

13.9.1.2 Behavioral Interventions During Late Childhood and Adolescence

Multicomponent treatments, including behavioral and family strategies, and cognitive-behavioral therapy are recommended in late childhood and adolescence. Like younger children, social learning theory is the framework of parenting components in these interventions. However, they show some differences from the interventions used for younger children. For instance, consequences of limit-setting may include loss of privileges in adolescents, instead of time out in younger children. The most established behavioral interventions are Multisystemic Therapy (MST) and Treatment Foster Care Oregon (TFCO) (Fairchild et al., 2019).

MST is delivered within the youth's daily environment by a treatment team that includes a therapist, behavior management specialist, and case manager (Henggeler et al., 2009). It aims to support adolescents' relationships with their prosocial peers and to improve their emotion regulation abilities, problem-solving skills, and school performance. MST is an intensive approach that typically continues during 3–-5 months and therapists should have multiple weekly face-to-face contacts with youth and their parents and on-call support consistently. A small efficacy of MST on delinquency was demonstrated in severe cases younger than 15 years of age (van der Stouwe et al., 2014). Additionally, antisocial behaviors and substance use were reduced in all age groups compared with usual treatment including family therapy and individual counseling. More treatment effect appears to be related to the use of intensive procedures to control the treatment quality by practitioners. However, data related to the efficacy of MST have been somewhat controversial, and a community-based multisite study in the United Kingdom found no long-term benefit of MST compared with standard care (Fonagy et al., 2020).

In TFCO, youth are placed in a foster home with trained foster caregivers during 6–9 months and a daily token-reinforcement system and age-appropriate clear limitations are implemented (Chamberlain, 2003). During this time, both intensive individual and group therapies are used for ameliorating social problem-solving skills, anger expression, and educational or vocational activities. Parents also receive intensive behavioral training that aimed to support the reintegration process of the youth into their natural community following the treatment. Several studies have demonstrated a decrease in delinquency and criminal referrals in both sexes, early pregnancy in girls, and violence in boys (Sinclair et al., 2016). However, the effects of TFCO appear to be limited to only cases who show mild or moderate severity.

Group-format cognitive behavioral therapy and Functional Family Therapy are other potentially effective treatments in adolescence (McCart & Sheidow, 2016; Sexton & Turner, 2010). Group-format cognitive behavioral therapy includes skills training programs for adolescents within community or detention facilities, whereas Functional Family Therapy is aimed at enhancing family problem-solving skills and emotional cohesion within the community. Emotion processing skills training is also beneficial for adolescents with CD who have CU traits (Dadds et al., 2012).

A systematic review showed that, for children older than 8 years, brief strategic family therapy to modify family interactions is the most effective intervention, with an effect size of 0.68 (Scotto Rosato et al., 2012). Regarding cognitive-behavioral therapy and multisystemic therapy which is targeted to increase parenting skills, family communication, and peer relationships, the effect size is 0.58 and 0.25, respectively (Scotto Rosato et al., 2012).

13.9.2 Special Education and Juvenile Justice or Detention System

Special education, youth welfare institutions, or the juvenile justice or detention system have been widely used for the management of children and adolescents with CD. Although well-controlled studies about the use of these facilities are limited, findings are not in favor of their efficacy (Fairchild et al., 2019). One study has detected that special education during secondary school elevates the risk of high school dropout and the severity of CD symptoms (Powers et al., 2016). In the United States, an increase in the frequency of psychiatric disorders, substance abuse, and suicidal behaviors in youth has been reported after detention (Abram et al., 2015). Additionally, a study detected an increase in criminal behaviors after youth incarceration (Gatti et al., 2009). Incarceration can also seem to cause additional psychiatric problems, such as posttraumatic stress disorder or major depressive disorder (Abram et al., 2015; Gatti et al., 2009). Therefore, the majority of widely used interventions for the management of CD in youth have no evidence of efficacy and can worsen the clinical situation due to iatrogenic effects.

13.9.3 Psychopharmacological Treatments

The primary treatment of CD is psychosocial interventions; however, research showed that psychopharmacological therapy could provide benefits in children and adolescents with CD and comorbid ADHD. Stimulants and antipsychotics are the most effective medications in these cases. Additionally, there is evidence regarding the potential efficacy of atomoxetine, clonidine, lithium, sodium valproate, and carbamazepine in children and adolescents with CD symptoms and coexisting ADHD.

Psychostimulants such as methylphenidate and amphetamine salts have efficacy on CD symptoms in children and adolescents with ADHD with moderate-to-large effect sizes (Pringsheim et al., 2015). Because of their propensity to cause metabolic, hormonal, and neurologic adverse effects, atypical antipsychotics are not recommended as first-line treatments for ADHD. However, moderate-quality evidence is available regarding the effect of risperidone on conduct problems and aggression in youth with subaverage IQ and CD with a moderate-to-large effect size (Reyes et al., 2006; Turgay et al., 2002). Thus, risperidone can be administered for the short-term treatment of severe CD. However, to date, the superiority of adding risperidone or another antipsychotic compared to using ADHD drugs has been still unclear. To avoid potential adverse effects, the lowest effective dose of risperidone should be commenced as indicated.

There is high-quality evidence for the small effect of atomoxetine on ODD symptoms in children with ADHD (Pringsheim et al., 2015); however, evidence regarding its impact on CD symptoms is very limited. Although the true effect may not be clinically significant, there is low-quality evidence regarding a small effect of clonidine on conduct problems in children and adolescents with ADHD (Pringsheim et al., 2015). Evidence supporting the effect of quetiapine, thioridazine, haloperidol, divalproex, and lithium in youth with CD is of low or very low quality (Pringsheim et al., 2015). There is also very low-quality evidence regarding no superiority of carbamazepine on placebo for the treatment of aggression in youth with CD (Pringsheim et al., 2015).

Randomized controlled trials such as multimodal treatment study of children with ADHD have not demonstrated extended effects of methylphenidate or non-drug interventions for preventing CD in children with ADHD (Swanson et al., 2017). Nevertheless, early detection and treatment of CD symptoms may have crucial importance regarding the prognosis of CD in ADHD. Psychopharmacological treatment should be commenced when CD symptoms are firstly detected in these cases. Clinicians should also address the challenges which reduce long-term compliance with pharmacological treatments for CD.

13.10 Prognosis

Longitudinal studies demonstrated that coexisting CD in children with ADHD increases the risk of ADHD persistence across time (Caye et al., 2016; Erskine et al., 2016). Additionally, coexisting CD in these children leads to worse outcomes in adulthood. However, data regarding the degree to which risks are carried by ADHD itself or early-onset coexisting CD are controversial. Some studies have demonstrated that coexisting CD accounts for many of the adversities including substance abuse, other mental health problems, school dropout, and criminal behaviors (Erskine et al., 2016). However, an ADHD follow-up study that focuses on the progress of children with ADHD without comorbid CD found elevated rates of antisocial personality disorder and other unfavorable social outcomes into adult midlife (Klein et al., 2012). These findings propose that the majority of negative outcomes observed in individuals with ADHD might not be explained by early-onset CD. However, in this study, cases with subthreshold CD might be considered as pure ADHD, though they carry higher risks for the emergence of CD symptoms.

Research generally addresses the behavioral and social outcomes of coexisting CD in ADHD. A large Danish registry study also displayed the effect of coexisting CD on mortality rates in individuals with ADHD (Dalsgaard et al., 2015). According to this study, the mortality rate ratio was 1.5 for individuals with ADHD alone, but this was 2.17 for those with the comorbid CD or ODD. This finding suggests that coexisting CD is related to poor outcomes for ADHD with respect to both psychosocial and physical well-being. Further studies are necessary to explain the potential mechanisms, prevent the development of these adversities, and optimize outcomes.

13.11 Conclusion

A variety of studies suggest that coexisting CD is related to more clinical impairment, more extensive neurodevelopmental burden, and poor psychiatric and functional outcomes in ADHD. The development of comorbid CD is not simply a consequence of ADHD and many factors such as elevated genetic risks, temperamental characteristics, neurodevelopmental problems including poor emotion regulation, language impairments, and low cognitive ability, and elevated levels of psychosocial adversity play roles in this process. The presence of CD should be cautiously evaluated by clinicians before making decisions on the intensity and nature of the treatment. Properly analyzing and addressing the potential psychosocial risk factors is an important step in the prevention of CD in children with ADHD. Establishing a well-functioning network between clinicians, families, and teachers is crucial. Further data are necessary to identify the developmental and causal pathways and better intervention strategies of CD in individuals with ADHD.

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ADHD and Depression

14

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Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder that affects approximately 1 in 10 children in the United States (Biederman, 2005; Biederman et al., 2010; Greydanus et al., 2007; Polanczyk et al., 2007). ADHD symptoms typically arise during childhood, and often persist into adulthood, with childhood ADHD symptom severity significantly predicting persistence into adulthood (Kessler et al., 2005). Moreover, ADHD is highly associated with comorbid conditions (Kessler et al., 1994), with the prevalence of co-occurring psychiatric disorders in children and adolescents ranging from about 40% to 80% (Elia et al., 2008; Gillberg et al., 2004; Larson et al., 2011; Yoshimasu et al., 2012). Major depressive disorder (MDD) is one of the most common lifetime comorbidities associated with ADHD (Secnik et al., 2005) and has been reported in epidemiological (e.g., Bird et al., 1988), family (e.g., Mick et al., 2003), and clinical studies (e.g., Pliszka, 1998; Spencer et al., 1999) of both children and adults. While it remains unclear whether co-occurring depression represents a distinct clinical subtype of ADHD (Biederman et al., 1996) or if depression is secondary to neurodevelopmental vulnerabilities associated with ADHD, the presence of comorbid depression results in more impairment than either disorder in isolation and complicates intervention efforts (Biederman et al., 2008, 2014). A more comprehensive understanding of the symptoms, risk factors, and underlying mechanisms driving the co-occurrence of ADHD and depressive disorders is essential for addressing the complex clinical picture of those with both disorders.

A large body of research, utilizing both cross-sectional (e.g., Ostrander et al., 2006) and longitudinal (e.g., Biederman et al., 2008) study designs, as well as community (e.g., Ferusson et al., 2010) and clinical samples (e.g., Busch et al., 2002), shows that depressive disorders occur at significantly higher rates in those with ADHD compared to those without. The association between the disorders has been documented in meta-analytic research as well. For example, Angold et al. (1999) found a strong association between ADHD and depression. A meta-analysis of family study data found a significant familial link between the two disorders (Faraone & Biederman, 1997), and a more recent meta-analysis of 29 cross-sectional and longitudinal studies found a medium effect for the association between ADHD and depression (Meinzer et al., 2014). In children and adolescents, studies show the rate of MDD is 5.5 times higher in youth with ADHD compared to those without (Angold et al., 1999), with rates ranging from 12% to 50% (Chronis-Tuscano et al., 2010; Elia et al., 2008; Pliszka, 1998). Further, rates of depression and

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ADHD co-occurrence seem to increase during the developmental period of adolescence (Pliszka, 1998; Spender et al., 1999) and persist into adulthood. Among adults with ADHD, MDD is one of the most common lifetime comorbidities, with rates ranging from 16% to 31% and rates of dysthymia ranging from 19% to 37% (Kessler et al., 2005).

ADHD and depression are individually associated with long-term negative outcomes, but their co-occurrence is associated with even greater levels of impairment and negative outcomes compared to those with either disorder alone; this includes greater psychosocial difficulties and higher rates of hospitalization (Biederman et al., 2008; Birmaher et al., 1996; Blackman et al., 2005; Cantwell, 1996; Daviss et al., 2006; James et al., 2004; Rohde et al., 1999). Moreover, studies indicate that comorbid ADHD and depression are associated with worse depression outcomes, including an earlier age of depression onset, a longer duration of illness, increased symptom severity, and greater functional impairment (Biederman et al., 2008). Chronis-Tuscano et al., (2010) found that 18.4% of children diagnosed with ADHD experienced recurrent depression by age 18, compared to only 1.6% of a matched control group. Importantly, the increased risk of depression associated with ADHD remains significant even after removing overlapping diagnostic criteria (Biederman et al., 1996; Milberger et al., 1995).

In addition to depression, a growing body of research suggests that ADHD may increase the risk of suicidal thoughts and behaviors (Bacskai et al., 2012; Chronis-Tuscano et al., 2010; Hinshaw et al., 2012; James et al., 2004). Though it is well-established that there is a significant relationship between suicidal thoughts and behaviors and depressive disorders in children and adolescents (Cho et al., 2008; Esposito & Clum, 2002; Ialongo et al., 2005; Nock et al., 2008), some research indicates that ADHD comorbidity increases risk (Agosti et al., 2011; Cho et al., 2008; Goldston et al., 2009; Impey & Huen, 2012; James et al., 2004). Using data from all suicide deaths of kids ages 5–14 in the United States that occurred between 2003 and 2012, Sheftall et al. (2016) found that ADHD was one of the most common diagnoses among children who died by suicide. Thus, ADHD may be an important risk factor for suicide even in early childhood and school-aged children. Longitudinal and meta-analytic work has shown that, compared to those without a diagnosis of ADHD, individuals with a childhood diagnosis of ADHD were almost two times as likely to consider suicide and seven times as likely to attempt suicide in high school (Barkley & Fischer, 2006). Further, by young adulthood, they are 2.6 times more likely to consider suicide (Barkley & Fischer, 2006) and have almost three times the risk of attempting suicide than controls (James et al., 2004).

Given the high rates of depression and suicidality associated with ADHD, it is imperative to better understand the nuances related to their co-occurrence. This chapter explores differential diagnosis (i.e., disentangling whether overlapping symptoms are attributable to one or both diagnoses), explanations/mechanisms by which ADHD confers risk for depression, avenues for treating comorbid depression and ADHD, and future directions for research in this area.

14.1 The DSM-5-TR Diagnostic Criteria for Depressive Disorders

To effectively identify and treat co-occurring ADHD and depression in clients, providers must appreciate the diagnostic criteria for depressive disorders as they apply to individuals across the lifespan. Perhaps the most well-known depressive disorder is major depressive disorder (MDD; American Psychiatric Association, 2013a). MDD is characterized by the occurrence of one or more discrete depressive episodes. A depressive episode must last at least 2 weeks, cause clinically significant distress or impairment in daily functioning, and include either (1) depressed mood in adults (e.g., feeling sad, empty, hopeless) or irritable mood in children, and/or (2) loss of interest or pleasure in all, or almost all, previously enjoyed activities nearly every day. In addition to one of the mentioned symptoms, an individual must experience four or more of the following nearly every day: weight loss or weight gain, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue or loss of energy, feelings of worthlessness or excessive or inappropriate guilt, difficulty concentrating, and recurrent thoughts of death. Importantly, the episode must not be attributable to the physiological effects of a substance or medical condition, cannot be better explained by a psychotic disorder, and should not be provided to someone who has had a manic or hypomanic episode. A selection of specifiers that further describe the nature of the MDD, such as MDD with anxious distress or atypical features, can be attached to the diagnosis to encourage clear communication between providers.

14.1.1 Differences in the Clinical Presentation of MDD and ADHD

Conceptually, ADHD and MDD share some general diagnostic features, including concentration difficulties and psychomotor agitation (American Psychiatric Association, 2022). As noted previously, ADHD and MDD are often comorbid, further complicating diagnostic decision-making (Bron et al., 2016). However, evidence suggests that even after accounting for these overlapping features among individuals with ADHD and comorbid depression symptoms, a distinct ADHD diagnosis remains (Barkley & Brown, 2008; Meinzer et al., 2014). Though researchers have hypothesized that ADHD-related impairment may contribute, in part, to the development and maintenance of MDD (Eadeh et al., 2017), an ADHD diagnosis comprises a clinical profile unique to that of MDD. Individuals with ADHD display consistent difficulty regulating attention and focus (including hyper-focusing), engage in impulsive and hyperactive behaviors, and exhibit global deficits in executive functioning (Brown, 2009). These diagnostic hallmarks of ADHD do not overlap with current criteria for MDD (Paucke et al., 2021). Further, though attention difficulties are seen in the diagnostic criteria of both ADHD and MDD, the attention deficits seen in ADHD are enduring and begin in childhood, whereas those seen in MDD are specific to the depressive episode. Additionally, irritability (i.e., an increased proneness to anger relative to peers at the same developmental level; Brotman et al., 2017) should be considered when addressing ADHD and depression in children. Irritability is a core symptom of depression in children and is reported in one-third of children with depression (Stringaris et al., 2012, 2015), and though irritability is not a defining diagnostic feature of ADHD, it is present in approximately 25–45% of children with the disorder (Shaw et al., 2014). Importantly, children with ADHD who also experience elevated irritability are at elevated risk of developing depression symptoms (Eyre et al., 2019). Thus, it is important to consider irritability, as it may be an early marker of mood problems in children with ADHD.

Despite the uniqueness of symptom expression across ADHD and MDD, both disorders do contribute to functional impairment in similar domains (e.g., sleep disturbances, higher rates of substance use, interpersonal relationship strain, and poorer academic performance; Alvaro et al., 2013; Arnold et al., 2020; Canu et al., 2008; Hunt et al., 2020; Lunsford-Avery et al., 2016; Owens et al., 2012; Wilens et al., 2011). In light of this declining functioning, individuals may be naturally curious to seek answers regarding *why* this impairment is occurring, a phenomenon commonly referred to as "health information seeking" (Mishra et al., 2009; Zimmerman & Shaw, 2020). Online search engines are often the quickest and most accessible method of accessing mental health information rapidly (Schueller et al., 2020). Adolescents and adults who frequently engage in online content may encounter information (or misinformation) regarding common psychiatric diagnoses like ADHD. Recent studies have concluded that a high percentage (79%; $N = 100$) of sampled social media content on ADHD is not based on empirical evidence (Yeung et al., 2023). Coupled with research suggesting that ADHD is often misdiagnosed (or even overdiagnosed), it is possible that symptoms of a mood disorder are misattributed to ADHD by both the patient and the provider (Giuliano & Geyer, 2017). The following example helps to further illustrate this point:

> A student begins experiencing concentration difficulties as a result of her newly depressed mood and anhedonia (two symptoms of MDD) and notices a decline in her work performance. She is highly aware of her perceived inability to pay attention in meetings and on tasks (as this is a deviation from her prior experiences) and seeks to understand why she is struggling with concentration. She searches "trouble paying attention causes" into a popular online search engine and is greeted with "Attention Deficit Hyperactivity Disorder (ADHD) In Adults" as the first suggested article.

Because ADHD symptoms cover a myriad of experiences and behaviors (e.g., difficulty following instructions, frequently losing things, acting without thinking), they may become an enticing explanation for this individual's presenting concerns (further supported by Fleischmann & Miller, 2013). This fictional character may attend to these attentional concerns more than the low mood and, in turn, seek out ADHD diagnostic testing (a theory put forth by Suhr & Wei, 2017). The job of the clinician is to then determine the driving factor of the present concentration concerns and parse apart whether the underlying issue maintaining the dysfunction is mood disturbances, neurocognitive deficits, or a combination of the two.

Considering the conceptual overlapping features of ADHD and MDD, high rates of diagnostic comorbidity, and shared functional impairments, it is imperative to first highlight relevant etiological, prognostic, and cognitive differences between these two diagnoses to inform the psychodiagnostic assessment process.

14.1.2 Etiological and Prognostic Differences

As a neurodevelopmental disorder, ADHD is best understood as a highly heritable "brain-based" disorder that broadly impacts self-regulation and contributes to deficits in executive functioning (Castellanos et al., 2006). Neurobiological research has suggested that underactivity in areas of the frontal cortex that regulate various cognitive and emotional processes may explain why general executive functioning deficits are a hallmark of ADHD (Wright, 2021). Research has identified prenatal risk factors (e.g., low birth weight, premature birth, lack of oxygen during birth), neuronal receptor density, and epigenetic etiological factors (Nigg, 2012; Sciberras et al., 2017; Sharma & Couture, 2014). Decades of research suggest that symptoms of ADHD emerge in childhood or early adolescence (Chandra et al., 2021; Cuffe et al., 2005). Generally, those with ADHD experience chronic and persistent impairment in attention and executive functioning that is independent of mood disturbances (Brown, 2009). Though symptoms of ADHD may worsen during periods of heightened anxiety or depression, these symptoms (and the affiliated functional impairment) persist even in the absence of internalizing symptoms (Jarrett et al., 2016).

While significant advances have been made in the field of ADHD etiology over the past 20 years, research on MDD etiology remains complicated (Wainwright & Galea, 2013). Genetic factors, trauma exposure, substance use, female gender, and comorbid illnesses have all been linked to MDD (Kenneson et al., 2013; Nelson et al., 2017; Villanueva, 2013). MDD is comprised of nine possible symptoms and, in turn, is highly heterogeneous among those who share this diagnosis. Symptom profiles can differ drastically from person to person as a result of which symptoms they endorse (Fried, 2017). MDD is also episodic in nature, meaning an individual may have episodes of depression that are followed by periods of euthymic mood and minimal functional impairment in various domains, including attention and executive functioning (Kalat, 2015). In contrast to ADHD diagnosis, there is no "age of onset" criterion for MDD; however, research suggests symptom onset typically occurs in adolescence or young adulthood (Lewinsohn et al., 1994; Wilson et al., 2015). MDD among children is less common, but prevalence rates are around 2% (Wagner et al., 2015).

14.1.3 Differences in Cognitive Functioning

Diagnostic criteria for both MDD and ADHD suggest similar difficulties in various areas of cognitive performance (e.g., motivation, concentration); however, the function of these symptoms differs between disorders. As outlined by Criterion A.8 of MDD in the DSM-5-TR, for example, the diminished ability to concentrate endorsed by many depressed individuals may appear reflective of the diagnostic criteria for general inattention caused by ADHD (Criterion A.1). An individual who is experiencing attentional concerns related to their depressed mood may meet clinical significance on self- or informant-report measures assessing inattention.

Neuropsychological tasks have also been utilized to investigate the presence of cognitive concerns among individuals with MDD and ADHD, independently and comorbidly. Interestingly, there is limited evidence to suggest that performance on neuropsychological tests measuring attention, executive functioning, and working memory is significantly impaired in individuals with MDD compared to non-depressed controls (Favre et al., 2009; Rohling et al., 2002). Vilgis et al. (2015) conducted a systematic review of attentional and executive functioning among children and adolescents with MDD. Studies included in the review yielded mixed results but generally did not find significant differences in performance across an array of neurocognitive measures between depressed and non-depressed participants (e.g., sustained attention as measured by continuous performance tasks; response inhibition as measured by the Stroop Task; set shifting as measured by the Trail Making Task and the Wisconsin Card Sorting Task; reward processing and decision-making as measured by the Iowa Gambling Task). Results are mixed regarding differences in working memory capabilities between depressed and non-depressed individuals. While some studies suggest impairment in working memory among individuals with MDD, others have not found significant differences between groups on measures of working memory (e.g., as measured by the Letter-Number Sequencing subtest of the Weschler Adult Intelligence Scale and the Weschler Intelligence Scale for Children; Lee et al., 2014; Russo et al., 2015).

On the contrary, individuals with ADHD have consistently shown significantly poorer performance on neuropsychological measures assessing these same domains (executive functioning, attention, and working memory) compared to their non-ADHD counterparts (Pievsky & McGrath, 2018; Rapport et al., 2008; Willcutt et al., 2005). While individuals with ADHD and individuals with MDD both exhibit reduced processing speed compared to healthy controls, the function of this neurocognitive deficit differs vastly based on disorder type. For example, among depressed individuals, slower processing speed may be best explained by psychomotor retardation (a symptom of MDD) compared to poor attention and concentration as seen in children with ADHD (Favre et al., 2009).

Taken together, there is an inconsistency between reported levels of inattention and executive functioning (as assessed by self- or informant reports) and outcomes on performance-based neuropsychological measures of these same domains among individuals with MDD. One potential explanation for this disparity could be the environment in which these constructs are assessed. As posited by Bornstein (2011), self- and informant reports constitute "typical functioning measures," assessments that evaluate a person's perception of their functioning in daily life. "Optimal functioning measures" assess an individual's cognitive performance abilities under optimal conditions (i.e., a controlled testing environment). Wright et al. (2021) have hypothesized that patients may report challenges with attention and executive functioning on typical functioning measures but achieve average scores on optimal functioning measures, indicating that their presenting concerns may be better explained by mood disturbances, including depression, than by a neurodevelopmental disorder like ADHD.

14.2 Psychodiagnostic Assessment Recommendations

Practitioners should consider the significant etiological and cognitive differences between ADHD and MDD when engaging in a psychodiagnostic assessment. To accomplish this in practice, clinicians should rely on a combination of (1) age-appropriate self- and informant-report measures, (2) neuropsychological tasks, and (3) clinical diagnostic interviews. Because the diagnostic validity of each of these three assessment types is compromised when used in isolation, clinicians should aim to integrate the findings of all three assessment types when making diagnostic decisions (Kooij et al., 2008; Young & Gudjonsson, 2005). For example, research has found significant discrepancies between self- and informant-report rankings on adult ADHD symptom rating scales (Kooij et al., 2008). This may be due to client tendencies to either underreport the severity of current and childhood symptoms (possibly due to a lack of symptom insight commonly found amongst individuals with ADHD) or intentionally overreport the nature of their concerns to access common secondary gains of an ADHD diagnosis (e.g., stimulant medications and accommodations; Cook et al., 2016; McGough & Barkley, 2004; von Wirth et al., 2021). Using the below-mentioned evidence-based assessment strategies may reduce the likelihood of malingering.

Empirically supported guidelines for assessing ADHD have been effectively summarized by Wright (2021). Here, the author suggests a 4-step approach for conducting an ADHD-focused psychodiagnostic assessment that includes an evaluation of (1) current and (2) past attentional and executive functioning concerns, (3) exhibited neurocognitive impairments (under optimal testing conditions), and (4) any differential diagnoses that better explain current impairments.

If an individual endorses symptoms of both MDD and ADHD, it is crucial to investigate the timeline of mood and ADHD-related symptoms, the function of reported symptoms, the course of affiliated impairment, and performance on neuropsychological tasks. General cultural considerations should also be acknowledged and addressed during the assessment process, including the impact of gender, race, and trauma history on testing outcomes.

One of the most important factors in differentiating ADHD from a myriad of other disorders (including MDD) is establishing a clear timeline of symptom onset and affiliated impairment. Current diagnostic criteria for ADHD (per the DSM-5-TR) require symptom presence before the age of 12. While this criterion has been contested in recent literature (Chandra et al., 2021), there is still minimal evidence to suggest high prevalence rates of "late-onset" ADHD in older adolescents and emerging adults (Cooper et al., 2018). Due to the neurodevelopmental nature of the disorder, ADHD symptoms should have emerged before or in early adolescence for a diagnosis to be considered. Conversely, symptoms of MDD can emerge at any time over the course of an individual's life (American Psychiatric Association, 2022). Because MDD is episodic in nature, establishing a clear timeline of symptoms is extremely helpful in further understanding an individual's baseline attentional abilities when not in a mood episode. This may further allow for the differentiation of attention-related concerns as they temporally relate to mood disturbances (e.g., concentration difficulties emerging when an individual is in an active MDD episode). Important questions clinicians may consider when generating a timeline of mood- and ADHD-related symptoms are summarized below. Further inquiries regarding separate, but related, domains are also included here (Table 14.1).

14.2.1 Context Is Key

In addition to symptom function and timeline, global impairment, and performance on neuropsychological evaluations, several other factors must be considered when differentiating ADHD

Table 14.1 Assessment questions to consider

Generating a timeline of symptoms	When did attentional or executive functioning difficulties emerge? Did they appear before adolescence (around age 12)? Do informant reports corroborate this age of onset? When did depression symptoms emerge? Does the onset of attentional or executive functioning concerns coincide with the onset of depression symptoms? If so, at what age was the onset of these symptoms? Do attentional or executive functioning concerns occur in conjunction with episodes of depressed mood? Or have they been consistent over the course of their lifetime regardless of significant mood changes? Did attentional or executive functioning difficulties emerge shortly after a traumatic event, adverse childhood experiences, a major life transition, or a diagnosed medical condition? If so, clinicians may consider investigating the possibility of another disorder (PTSD, Adjustment Disorder, MDD, or bereavement) as a better explanation for ADHD-like concerns.
Assessing impairment/function of symptoms	Is there consistent impairment in more than two life areas (e.g., school and work) since attentional symptoms emerged? If not, ADHD may not be the best explanation for the symptoms. Are attentional concerns the result of distractibility (pointing to ADHD) or lack of interest/low mood/fatigue (pointing more toward mood disturbances like MDD)? Do informant reports corroborate this symptom endorsement/impairment?
Assessing performance on neuropsychological tasks	Are there deficits in working memory or processing speed? Are there deficits in set shifting, sustained attention, or response inhibition? ADHD may be more likely than a mood disorder if these attentional and executive functioning concerns (apart from decreased processing speed) are present, though this is not always the case. Is there documented impairment captured via "typical functioning" measures (i.e., self- and informant reports of ADHD symptoms and executive functioning) and "optimal functioning" measures (i.e., neuropsychological tasks)? If so, further examination into the possibility of an ADHD diagnosis should be considered. What are the examinee's intellectual abilities (e.g., assessed through an intelligence test)? Research indicates that general intelligence can moderate impairment among individuals with ADHD (Costa et al., 2014; Rommelse et al., 2017). The lack of neurocognitive deficits is not always synonymous with the presence of ADHD.

from depressive disorders. These include, but are not limited to, environmental, cultural, social, and developmental circumstances. Some areas that warrant specific attention during a psychodiagnostic assessment are highlighted below.

1. *Gender Differences Among Rates of MDD and ADHD:* Researchers have historically highlighted higher base rates of MDD in girls and women compared to boys and men (Essau et al., 2010). Researchers have attempted to explain this prevalence disparity by highlighting how current MDD diagnostic criteria are comprised primarily of internalizing symptoms. These criteria, psychologists argue, neglect the role of externalizing behaviors in males experiences with depression, contributing to a widening diagnostic gap (Cole & Davidson, 2019). Conversely, ADHD is diagnosed far more frequently among boys and men than girls and women, with some research documenting a 9:1 ratio of male to female ADHD diagnoses (Rucklidge, 2008). ADHD symptoms are often ignored or misdiagnosed among girls due to societal pressures to inhibit hyperactivity, contributing to symptom masking (Chronis-Tuscano, 2022). Paired with the diagnostic criteria for ADHD (which have been critiqued for their overreliance on

behavioral symptoms; Wright, 2021), psychologists are limited in their understanding of girls (and women's) experiences with ADHD. Clinicians may be tempted to attend more to anxiety- and depression-related symptoms compared to legitimate attentional and/or psychomotor concerns (Chronis-Tuscano, 2022) when working with female clients. Clinicians must consider the role of gender expression and stereotypes within medical settings when differentiating ADHD from MDD.

2. *Trauma-Informed Perspectives:* Trauma-informed approaches, especially when working with children, are also important to consider when assessing the presence of ADHD and MDD symptoms. Specifically, symptoms of post-traumatic stress disorder (PTSD) and/or MDD can result from adverse childhood experiences (ACES; Burke et al., 2011) or traumatic events that mimic symptoms of ADHD, such as inattention, sleep issues, and disorganization (Szymanski et al., 2011). Unfortunately, trauma is common, and data suggests that anywhere between 51% and 80% of individuals will experience a traumatic event at some point in their lifetime (de Vries & Olff, 2009; Friedman et al., 2021; Mills et al., 2011). Because of this high prevalence, post-trauma symptoms should be assessed and considered when diagnosing mood and/or neurodevelopmental disorders.
3. *Limitations of Neuropsychological Testing:* There are significant limitations regarding neuropsychological testing for various populations, including gender-diverse clients, individuals whose first language is not English, and certain racial and ethnic minorities. Many neuropsychological tests used today were originally developed by and normed on White males, which has posed significant barriers to conducting culturally competent assessments over the past 50–100 years (Cory, 2020). While progress has been made in addressing this lack of diversity (e.g., through re-norming and the development of new measures), several limitations still exist today that pose dilemmas for clinicians. One relevant example is assessing non-binary or transgender clients using measures that are normed on a gender binary (i.e., male and female norms). While the APA encourages clinicians to (1) use combined gender norms when possible and (2) directly ask the client which norms they prefer, very limited empirical research exists on how to best address this issue in practice.

Each of the considerations discussed above has significant diagnostic implications. Personal characteristics, developmental history, and systemic factors should routinely be weighed when interpreting assessment results and considering the implications of a documented diagnosis. Clinicians should be mindful of the client's lived experiences that may shape symptom expression, access to care, and attitudes toward medical professionals. Additionally, providers are encouraged to research and implement current best practices in the field (e.g., by reviewing the American Psychological Association's professional practice guidelines).

14.3 Suggested Assessment Tools

There is no one standard assessment battery that can accurately differentiate between MDD and ADHD for all clients; clinicians may consider employing some of the following measures and neuropsychological tests to inform the diagnostic process. Please note that this is a sampling of commonly used assessment tools and not an exhaustive list (Table 14.2).

14.3.1 General Testing Considerations and Conclusions

It is important to consider that a significant amount of empirical evidence suggests ADHD is a neurocognitive disorder that contains behavioral features (Wright, 2021). However, the current diagnostic criteria set forth by the DSM-5-TR (American Psychiatric Association, 2022) are

Table 14.2 Suggested assessment tools

Assessment type	Pediatric populations	Adult populations
Clinical diagnostic interviews	Kiddie Schedule for Affective Disorders and Schizophrenia *(K-SADS)*	Structured Clinical Interview for DSM-5 – Clinician Version *(SCID-V-CV)* Diagnostic Interview for Anxiety, Mood, and Obsessive-Compulsive and Related Neuropsychiatric Disorders *(DIAMOND)*
Self- and informant-report measures	ADHD: Vanderbilt NICHQ ADHD Rating Scales *(Teacher and Caregiver/Parent)* Disruptive Behavior Disorder Rating Scale (DBDRS) *(Teacher and Caregiver/ Parent)* Swanson, Nolan and Pelham Teacher and Parent Rating Scale (SNAP-IV) Executive functioning: Behavior Rating Inventory of Executive Function – Second Edition (BRIEF-2) *(Self, Informant)* Depression: Children's Depression Inventory – Second Edition (CDI-2) *(Self, Informant)* Reynolds Adolescent Depression Scale – Second Edition (RADS-2) *(Self, Informant)* Anxiety: Multidimensional Anxiety Scale for Children – Second Edition (MASC-2) *(Self, Informant)* Screen for Child Anxiety Related Disorders (SCARED) *(Self, Informant)*	ADHD: Barkley Adult ADHD Rating Scale – Fourth Edition (BAARS-IV) *(Self and Informant: Current and Childhood Symptoms)* Conners' Adult ADHD Rating Scales (CAARS) *(Self and Observer Report)* Executive functioning: Behavior Rating Inventory of Executive Function–Adult Version (BRIEF-A) *(Self and Informant: Current Symptoms)* Barkley Deficits in Executive Functioning Scale (BDEFS) *(Self and Other Report)* Depression: Beck Depression Inventory – Second Edition (BDI-II) Center for Epidemiologic Studies Depression Scale (CES-D) Anxiety: Beck Anxiety Inventory (BAI) Generalized Anxiety Disorder 7-Item (GAD-7)
Neuropsychological batteries	Intelligence: Weschler Intelligence Scale for Children – Fifth Edition (WISC-V) Stanford-Binet IQ Test[a] Executive functioning: Delis-Kaplan Executive Function System (D-KEFS) Wisconsin Card Sorting Task (WCST) Dimensional Change Card Sorting Task (DCCST) Trail Making Test (TMT) Stroop Color and Word Test (SCWT) Conners Continuous Performance Test – Third Edition (CPT-3) Conners Continuous Auditory Test of Attention (CATA)	Intelligence: Weschler Adult Intelligence Scale – Fourth Edition (WAIS-IV) Executive functioning: Delis-Kaplan Executive Function System (D-KEFS) Wisconsin Card Sorting Task (WCST) Trail Making Test (TMT) Stroop Color and Word Test (SCWT) Conners Continuous Performance Test – Third Edition (CPT-3) Conners Continuous Auditory Test of Attention (CATA)

[a]For clinicians interested in a general intelligence test that places less influence on verbal abilities, the Stanford-Binet IQ test may be a suitable option. While the Stanford-Binet IQ test does not include subtests that explicitly examine processing speed, working memory is assessed.

heavily comprised of behaviorally based symptoms. While this may make the detection of DSM-5-TR ADHD symptoms by caregivers and peers easier, it neglects the neurological underpinnings that contribute to the onset and maintenance of this disorder. Researchers have also hypothesized that the current diagnostic criteria may inadvertently contribute to the imbalance of ADHD diagnoses across genders, with boys typically exhibiting more behavioral dysfunction than girls (Wright, 2021). Taken together, clinicians may consider incorporating neurocognitive tasks into their assessment battery for more comprehensive and reliable diagnostic assessments of these disorders. Doing so may not only address these diagnostic limitations of ADHD (i.e., overemphasis on behavioral rather than cognitive features) but can also aid in differentiating ADHD from MDD.

14.4 Explanations for the Co-Occurrence of ADHD and Depression

In addition to understanding the high rates of ADHD and depressive disorder comorbidity and best practices for differential diagnoses, it is imperative to consider the mechanisms that underlie their co-occurrence. Multiple theories have emerged from this area of research. One set of theories suggests that ADHD and depressive disorders simultaneously arise due to the interplay of multiple "common causes," or shared etiological factors (genetic, neurobiological, and environmental). Other theories assert that depression arises as a result of the secondary impairments associated with childhood ADHD symptoms, including social and academic difficulties. Findings and limitations from both theoretical perspectives will be discussed, along with specific considerations related to individual and contextual protective and risk factors for comorbid ADHD and depression.

14.4.1 Shared Etiology Theory

Genetic and environmental risk theories point to "common cause" endophenotypes that underlie both ADHD and depressive disorders. Research has illustrated the clear importance of genetic factors and neurobiological constructs (e.g., reward responsivity, emotion regulation) that relate to the etiology of both disorders. Environmental stressors (e.g., quality of parenting, family context, lack of access to care) may also serve to exacerbate the risk of comorbidity.

The Neurobiology of Co-occurring ADHD and Depression Research on the neurobiological processes that underlie both ADHD and depressive disorders represents a relatively new but growing body of literature (Meinzer et al., 2014; Pizzagalli et al., 2005; Seymour & Miller, 2017). Advances in genome mapping and neuroimaging technologies (e.g., fMRI, EEG) have permitted scientists to explore how genetics, neural circuitry, and associated brain structures interact with environmental factors to affect the development of psychopathology. Irregularities in these systems have been observed to negatively impact emotion regulation, reward responsivity, cognitive processes, and executive function in ways that appear to contribute to the co-occurrence of ADHD and depression (Gardner et al., 2009; Knouse et al., 2013a, b; Meinzer et al., 2012, 2014; Riglin et al., 2021; Seymour et al., 2014; Seymour & Miller, 2017; Taubitz et al., 2015; Vakalopoulos, 2007; Yung et al., 2020).

Shared Genetic Factors Genetics is the scientific study of how human traits are passed from parents to offspring due to changes in DNA sequence (National Institute of General Medical Sciences, 2022). Genes, the most basic physical and functional units of heredity, play a crucial role in the development of co-occurring ADHD and depression. Evidence suggests that both disorders are heritable, with ADHD considered highly heritable (approximately 80%; Faraone et al., 2005) and depression considered moderately heritable (approximately 40%; Wray et al., 2012). Several twin studies have found that up to 70% of the co-occurrence of ADHD and depression can be explained by shared genetic factors (Faraone & Larsson, 2019; J. Cole et al., 2009; Rydell et al., 2017; Spatola et al., 2007). At present, no one gene is believed to significantly influence the development of either disorder alone or in tandem. Instead, scientists suspect it is the more minor influence of many genes that contributes to the development of ADHD and depression (Faraone & Larsson, 2019). Powell et al. (2021) performed a meta-analysis on data from Genome-Wide Association Studies (GWAS) and identified 14 single nucleotide polymorphisms (SNPs), a variation at a single position in a DNA sequence, associated with both ADHD and depression. This research provides support for the presence of a common genetic pathway promoting the comorbid presentation of these disorders.

Shared Brain Structure Aberrant activity in shared brain structures may help to explain ADHD and depression comorbidity. Consistent with previous research (Douet et al., 2014; Naranjo et al., 2001; Powell & Voeller, 2004), Gardner et al. (2009) found that individuals with ADHD and depression comorbidity exhibited abnormal activity in the cerebellum and frontal brain regions. The cerebellum is involved in cognitive processing as well as behavioral and emotional control. Meanwhile, the frontal regions of the brain encompass the prefrontal cortex and limbic system structures (the hippocampus and amygdala, in particular), which have been implicated in executive dysfunction (Maletic et al., 2007; Powell & Voeller, 2004) and affective dysregulation (Plessen et al., 2006) across psychopathologies. Brain size and volume have been explored in a limited capacity, with some evidence pointing to smaller hippocampus volumes in individuals with ADHD and a history of depression but not in those without a history of depression (Onnink et al., 2014), as well as an enlarged amygdala (Perlov et al., 2008).

Shared Endophenotypes Endophenotypes are the neurological traits that interact to determine a final, observable feature or behavior, a phenotype, which may or may not be abnormal (Kendler & Neale, 2010). When studying psychopathology, researchers theorize that endophenotypes are caused by neurocognitive abnormalities in both the brain structure and neural circuitry, which may then increase an individual's risk of developing a disorder (Gottesman & Gould, 2003). Specific endophenotypes that ADHD and MDD may share are reward responsiveness (Meinzer et al., 2012), emotional processing/regulation (Gardner et al., 2009; Seymour et al., 2012, 2014), and executive functioning (Chang et al., 2020).

Reward responsiveness (i.e., an individual's ability to feel pleasure in anticipation and in the presence of reward-related stimuli; Taubitz et al., 2015) is a well-researched neuropsychological mechanism thought to explain comorbid ADHD and depression. The neural activity associated with this phenomenon occurs in the dopamine-mediated reward circuitry located in the ventral tegmental area (VTA) of the midbrain (Naranjo et al., 2001), and genes moderating the neurotransmitters that fire along this pathway have been associated with both ADHD (Wood & Neale, 2010) and MDD (Kato, 2007). The primary neurotransmitter associated with this pathway is dopamine, which provides individuals with feelings of pleasure in response to stimuli perceived to be rewarding and, thus, motivates them to seek out continued interaction with those stimuli (Arias-Carrión et al., 2010; Volkow et al., 2009). Dopamine is believed to interact closely with serotonin, a neurotransmitter essential in stabilizing mood, to influence an individual's psychological well-being (Blum et al., 2008). Broadly, dysfunction in this area may present as a loss of interest in previously enjoyed activities, prevent an individual from engaging in goal-directed behavior, dull one's anticipation for expected rewards, disrupt one's ability to evaluate the perceived costs and benefits of rewards, inhibit effective estimation of the amount of effort required to attain rewards, be unsure whether the effort was sufficiently rewarded, and lack the motivation to execute actions required to attain rewards. These deficits are directly related to negative affect, low motivation, inattention, and depression (Beauchaine & Zisner, 2017; Durston, 2003; Epstein et al., 2006; Pizzagalli et al., 2005) and include phenomena such as low hedonic tone and sluggish cognitive tempo (SCT).

An individual's initial and innate baseline ability to experience pleasure, often called a "set point," is largely a function of genetic expression

(Keedwell et al., 2005). Low reward responsivity has been identified in depression as impacting the severity of anhedonic symptoms (Pizzagalli et al., 2005; Shankman et al., 2007) and in ADHD as a desire for increased stimulation to overcome a naturally low set point and feel pleasure (Sternat & Katzman, 2016). In both disorders, reward responsivity can prevent individuals from anticipating expected rewards, accurately ascertaining the amount of effort required to attain a reward, and engaging in goal-directed behaviors to attain a reward (Sternat & Katzman, 2016). In one study, reward responsiveness was shown to mediate the relationship between ADHD and depression (Meinzer et al., 2012).

Though research examining any aspect of reward processing across ADHD subtypes is scarce, SCT is related to reward responsiveness and may represent another shared risk factor for inattentive ADHD symptoms and depression (Derefinko et al., 2008). SCT is a construct that represents marked drowsiness, daydreaming, mental confusion, and forgetfulness. It may be that SCT can help to explain the disproportionately frequent internalizing symptoms individuals with the inattentive subtype experience compared with their hyperactive and combined type peers (Hinshaw, 1994; Lahey & Carlson, 1991; Lahey et al., 1988).

An additional construct that might serve as a shared endophenotype for ADHD and MDD is emotion dysregulation. Emotion dysregulation is defined as an individual’s inability to modulate their emotional state so that it promotes adaptive, goal-oriented behaviors (Thompson, 1994) and can be conceptualized as an emotional expression that is excessive relative to social norms, rapidly occurring, and poorly controlled, and as a maladaptive allocation of attention to emotional stimuli (Seymour et al., 2014). Research suggests that emotion dysregulation is a shared etiological risk factor for ADHD and depression (Meinzer et al., 2014). Emotion dysregulation may also act in tandem with reward responsiveness. Children with ADHD and a low hedonic tone may experience increased sensitivity to rewards and, thus, suffer from heightened frustration when the reward is withheld (Seymour & Miller, 2017). Being unable to experience pleasure begets irritability, which is a symptom of both depression and ADHD (American Psychiatric Association, 2013a; Seymour & Miller, 2017). Functional magnetic resonance imaging (fMRI) studies have uncovered limbic system abnormalities (principally in the amygdala, thalamus, and hippocampus) that contribute to an over-perception of negative stimuli in ADHD (Plessen et al., 2006). Researchers have theorized that poor frustration tolerance combined with an over-perception of negative stimuli not only exacerbates emotional dysfunction in individuals with this comorbidity (Melnick & Hinshaw, 2000; Walcott & Landau, 2004; Wheeler & Carlson, 2000) but is also predictive of future depressive episodes (Durbin & Shafir, 2008; Tortella-Feliu et al., 2010).

A third potential endophenotype for ADHD and MDD is executive dysfunction. Executive dysfunction is defined as the self-regulatory neurocognitive processes that operate over time to help people achieve their goals (Barkley, 2013). These processes are largely located in the prefrontal cortex of the brain and have been implicated in comorbid ADHD and depression (Powell & Voeller, 2004). Impulsivity, poor inhibitory control, impaired reasoning ability, cognitive inflexibility, poor working memory, and difficulty task switching are all associated with a hypofunctioning dopamine system (Knouse et al., 2013a, b; Vakalopoulos, 2007). Although no studies to date have explored how these endophenotypes interact to impact the severity and frequency of comorbid ADHD and depression, it is possible to see how any single mechanism could be applied to the shared etiology model or causality model of this phenomenon. For example, impulse and inhibitory control are trans-diagnostic mechanisms governed by a myriad of areas in the frontal lobe (Alvarez & Emory, 2006; Aron et al., 2004). In ADHD, these mechanisms are apparent in an individual's behavior and intrinsic to the disorder’s criteria (American Psychiatric Association, 2013b). In depression, the same impulsive tendency may manifest as suicidal ideation and irritability (Vakalopoulos, 2007), or impulsive behaviors may result in consequences that maintain or worsen the depressed mood (Durbin & Shafir, 2008).

14.4.2 Social and Environmental Factors

The influence of neurobiological and genetic factors should not be understood in isolation, but rather, within a social and environmental context. Multiple factors related to familial and peer relationships, as well as academic functioning, may exacerbate existing genetic and neurobiological risks and/or may be salient contributors in themselves to the development of comorbid depressive disorders amongst individuals with ADHD.

Family Factors The inattentive, hyperactive, and impulsive behaviors and associated impairments that characterize childhood ADHD may provoke negative and inconsistent parenting styles and contribute to communication difficulties within families (Danforth et al., 1991). Specific parenting factors, including inconsistent management of children's disruptive behaviors (Ostrander & Herman, 2006), parent-child relationship difficulties (Humphreys et al., 2013), and low parental support (Pojanapotha et al., 2021), have all been found to be important and significant mediators in the relationship between ADHD symptoms and depression.

Family factors may have a differential impact on depression risk across developmental stages. For example, a study in a community sample found that for children under the age of eight, parent management alone significantly mediated the link between ADHD symptoms and depression (Ostrander & Herman, 2006). However, the same findings were not seen for older youth (i.e., children ages 10 and up). Instead, child cognitive factors, such as an external locus of control, mediated the impact of parenting behavior on depression symptoms within this age group. This sense of autonomy was also included in a study in which maternal and paternal support (comprised of warmth, monitoring, and involvement) mediated the relationship between ADHD and depression symptoms (Meinzer et al., 2015).

Other studies have highlighted the importance of parent-child relationship quality in ADHD and depression comorbidity. One longitudinal study (Powell et al., 2021) found that positive parent-child relationship quality had a buffering effect; friendship quality mediated the relationship between ADHD symptoms and depression, but this mediation was weaker among those who had warmer relationships with their parents. A second longitudinal study analyzed worsening relationship quality with mothers during adolescence as a mediator in the relationship between ADHD symptoms and depression (Meinzer et al., 2021a, b). Findings indicate that boys in the sample reported sharper decreases in relationship quality with their mothers and that this, in turn, explained the relationship between their elevated ADHD symptoms and depression symptoms. Taken together, parent-child relationships play a critical role in the development of depression symptoms among youth with ADHD, perhaps particularly for adolescent boys.

In addition to parenting practices and parent-child relationship factors, parental mental health, particularly maternal depression, may also impact the emergence of depression among those with ADHD. Epidemiological studies suggest that over 50% of children with behavioral disorders have a mother with depression (Chronis et al., 2003). Additionally, one longitudinal study of children with ADHD (Chronis-Tuscano et al., 2010) found maternal depression to be a significant predictor of children experiencing depression and suicidal behavior in adolescence.

Demoralization Theory Youth with ADHD experience substantial impairments in social and academic domains of functioning. Compared to their peers, children with ADHD are more likely to struggle in school; they receive lower grades and are at higher risk of dropping out (Herman et al., 2007; Kent et al., 2011). Additionally, children with ADHD have greater social difficulty, report fewer friends, and are at higher risk for peer victimization and bullying (Hoza et al., 2005; Ostrander & Herman, 2006). In the school context, the two areas of difficulty coalesce, as children with ADHD may experience academic and peer difficulties simultaneously. In turn, both academic and social impairments in childhood predict depression symptoms (McCarty et al., 2008; Seroczynski et al., 1997). The dual-failure model, or "demoralization theory" (Biederman et al., 1998), suggests that over time these compounding peer and classroom-related difficulties will be internalized by youth with ADHD as failures, contributing to a negative self-concept and leading to depression symptoms (Eadeh et al., 2017; Patterson & Stoolmiller, 1991).

The demoralization theory of ADHD and depression comorbidity is consistent with competency models of childhood depression (Cole et al., 2001), which describe how children's sense of self-concept can be formed and reinforced by messaging from others (e.g., parents, teachers) regarding their impairments, such as negative feedback or blame in response to their academic and social difficulties. These self-perceptions in early childhood can serve as the basis for cognitive distortions and depression symptoms in later childhood and adolescence (Cole et al., 2001; Herman et al., 2007). This model is supported by typical symptom onset: ADHD symptoms begin to appear in early childhood, while the onset of depressive disorders generally follows in late adolescence (Daviss, 2008).

Researchers have tested the demoralization theory by investigating the mediational role of ADHD-related academic and social impairment in the relationship between childhood ADHD symptoms and later depression symptoms. One study (Herman et al., 2007) supported the demoralization hypothesis as it relates to academic impairment in that academic performance mediated the observed relationship between attention difficulties and subsequent depression symptoms (even after the authors controlled for baseline academic difficulties and conduct problems). Another longitudinal population-based cohort study (Roy et al., 2015) demonstrated that peer dislike and victimization significantly mediated the association between ADHD symptoms and depression symptoms. However, when data were stratified by gender, the mediation was significant only for girls and not boys. The authors presented two possible explanations for observed gender differences: Girls may be more sensitive to peer opinions than boys (Bakker et al., 2010). Additionally, because many behaviors related to ADHD (e.g., hyperactivity) are more normalized in boys, they may be labeled as gender "inappropriate" in girls (de Boo & Prins, 2007), which could contribute to less tolerance from peers and a greater risk for depressive outcomes. Additionally, results of a large-scale longitudinal birth cohort study (V. Powell et al., 2020) found that peer problems (e.g., friendship quality, feeling liked by others, being bullied) and academic attainment at age 16 both significantly mediated the association between childhood ADHD symptoms and depression symptoms at age 17.5.

Contrary to the support suggesting academic and social impairment explain the relationship between ADHD and depression, multiple studies have countered the demoralization hypothesis and pointed to additional variables that may better explain the mechanisms underlying the association between ADHD and depression. One study found that both adolescent-parent conflict and peer difficulties, but not academic impairment, mediated the relationship between ADHD and depression (Humphreys et al., 2013). A longitudinal study demonstrated that MDD episodes in youth with ADHD persisted independently of ADHD-related impairment and school dysfunction (Biederman et al., 1998). Additionally, one study found that children with ADHD were still at increased risk of depression even after accounting for ADHD-related academic and social impairment (Meinzer et al., 2013). These studies indicate that, though academic and social impairments play a role in ADHD and MDD comorbidity, they are not solely responsible for their relationship.

14.5 Protective Factors

14.5.1 Cognitive Thinking Styles

Research on individual factors related to child thinking styles and treatment histories may point to mechanisms that promote resilience in the development of depressive disorders. Many children with ADHD form judgments regarding their abilities in an overly optimistic manner, a phenomenon labeled "positive illusory bias" (Hoza et al., 2002). However, there is less evidence for positive illusory bias in children who experience co-occurring depression symptoms (Hoza et al., 2004). Research shows that decreases in positive illusory bias over time are associated with an increase in depression symptoms (Hoza et al., 2010). This initial evidence suggests that children who form negative appraisals related to their abilities, which may mirror the harsh judgments of peers and teachers, are more likely to have comorbid depression, whereas children who maintain high self-esteem despite ADHD-related impairment may be protected. On the other hand, the positive illusory bias may also set children up for further failure and demoralization by preventing them from recognizing their difficulties and changing behavior in response to negative feedback (Owens et al., 2007). More research is needed to test the function of the positive illusory bias and to understand its adaptive and/or maladaptive consequences. In addition to the positive illusory bias, having less ruminative thinking and avoidant cognitive styles was protective against depression among adults with ADHD (Oddo et al., 2018).

14.5.2 Treatment Access

In addition to individual cognitive factors, treatment for ADHD symptoms in childhood may also be protective in the ADHD-depression trajectory. One study found that the more years of treatment for ADHD (of any modality), the lower the likelihood of having co-occurring depression (Oddo et al., 2018). A second study found that the association between childhood ADHD and depression was no longer significant when accounting for the persistence of ADHD symptoms (Meinzer et al., 2016), further supporting the potential protective effect of early treatment for ADHD (Meinzer & Chronis-Tuscano, 2017). Given that treating ADHD in childhood appears to be key to preventing negative outcomes and lessening the risk of comorbid depression, lack of access to treatment may be an important environmental risk factor related to increased symptom severity. Early treatment access may also serve to lessen parenting stress.

When considering treatment access as a protective factor, it is imperative to take into account the disproportionate lack of access to treatment experienced by families of color. Prevalence rates of ADHD are consistent across cultures and racial groups, but children of color in the United States (particularly Black children) are less likely to be diagnosed with ADHD, receive any evidence-based treatment, or stick with treatment once initiated as compared to their White peers (McKay et al., 2001; Whitaker et al., 2018). Though research in this area is limited, some reasons have been proposed that underlie these documented mental health care disparities. At the family level, cultural factors include ADHD-related stigma and the lack of recognition of ADHD as a neurodevelopmental condition (Kendall & Hatton, 2002; Slobodin & Masalha, 2020), both of which can contribute to parents not seeking treatment for their child's ADHD symptoms and to parents being blamed by friends and family for their child's behavior (Kendall & Hatton, 2002). Within the medical system, health care providers' dismissiveness and lack of cultural competence may contribute to ADHD treatment delays and a lack of engagement in care (Spencer et al., 2021). In schools, some scholars argue that the underdiagnosis of Black children may be in part driven by the disproportionate punishment of Black children's behaviors in classroom settings (Moody, 2016). Teachers in the United States, the majority of whom are White, may perceive Black students' ADHD-related behaviors (e.g., hyperactivity) as "disruptive" rather than as symptoms of a neurodevelopmental disorder worthy of evaluation and treatment. In turn, punishment and exclusion of children in school settings are linked to increased psychological distress in children (Ford et al., 2018). The unequal treatment of children and families of color by doctors and teachers highlights the ways in which systemic racism contributes to disparities in access to care for ADHD, compounding children's risk for depressive disorders.

14.6 Treatment Recommendations

14.6.1 Psychopharmacology

Several studies have explored the effects of pharmacological interventions for treating concurrent ADHD and depression. There are two prevailing (though not incompatible) theories regarding medication treatment for individuals with ADHD and comorbid depression. The first school of thought regarding medication recommendations draws from literature suggesting that treating ADHD alone may have downstream effects on depression. In a longitudinal study of individuals with ADHD, both ADHD medication use (i.e., history of any ADHD medication use) and the duration of ADHD medication use were associated with lower rates of medical visits related to depression symptoms (Chang et al., 2016). These findings are consistent with the demoralization theory previously discussed (Biederman et al., 1998; Hoza et al., 2005; Ostrander & Herman, 2006). Therefore, one recommendation is to first treat ADHD with either stimulant medication or non-stimulant medication that is approved for ADHD (Hughes et al., 1999; Turgay & Ansari, 2006). After monitoring both ADHD and depression symptoms, if the ADHD medication is well tolerated and effectively addresses ADHD symptoms, but depression symptoms continue to persist, then an antidepressant medication is recommended to be added in conjunction with the ADHD medication (Hughes et al., 1999; Turgay & Ansari, 2006). Taking both ADHD medication and antidepressant medication together is both safe and effective (Gammon & Brown, 1993; Kratochvil et al., 2005; Pataki et al., 1993; Rapport et al., 1993).

Alternatively, other guidelines suggest that the more severe disorder should be treated first (Turgay & Ansari, 2006); if depression is particularly severe, namely if there are safety concerns due to suicidality, it is recommended that the depression symptoms be pharmacologically treated first. Then, when symptoms become more manageable, it is appropriate to introduce ADHD medication (Mattingly et al., 2021; McGough, 2016; Turgay & Ansari, 2006). Likewise, if ADHD is the primary source of impairment, it is recommended that (1) ADHD be treated first, (2) monitor the effect of the treatment on depression symptoms, and (3) then introduce pharmacological treatment for depression if it is necessary.

14.6.2 Psychosocial Treatments

Though several psychosocial interventions have been studied or proposed as potentially beneficial for those with comorbid ADHD and comorbid depression symptoms (Daviss, 2010), cognitive-behavioral therapy (CBT) is perhaps the most widely researched. CBT targets maladaptive cognitions and behaviors that are observed across various psychopathologies and aims to improve symptoms by restructuring thoughts and maladaptive behaviors. Multiple trials have employed ADHD-focused CBT programs alone or in conjunction with ADHD medication for individuals with ADHD (Safren et al., 2010; Solanto et al., 2010). Given the high prevalence of depression symptoms among those with ADHD, researchers have tended to examine depressive symptom changes within these trials (Rostain & Ramsey, 2006; Safren et al., 2005; Safren, 2006; Stevenson et al., 2002; Young & Amarasinghe, 2010). CBT for ADHD addresses key ADHD symptoms such as organization and planning, distractibility, and adaptive thinking, in addition to optional modules that address other common symptoms such as procrastination, communication, and frustration management. Within several trials, those who were randomized to the

CBT program experienced both reductions in ADHD symptoms and impairment as well as depression symptoms (e.g., Rostain & Ramsey, 2006; Safren, 2006). Therapy in conjunction with medication has increased in prevalence among clinical recommendations for treating depression symptoms in those with ADHD (Daviss, 2008; Safren, 2006). Part of this rationale is that medications can provide a bottom-up approach to treatment by targeting executive functioning symptoms, and CBT can provide a top-down approach to treatment by developing a cognitive framework that can be deployed in ways that address ADHD-related impairments. These frameworks also promote resilience in the context of other psychopathology, namely, depression symptoms (Rostain & Ramsey, 2006).

Additionally, changes in depression symptoms among adolescents with ADHD have been examined within the seminal treatment for adolescents with depression (TADS; March et al. 2007) study of individuals with depression. In a TADS outcome study evaluating all adolescents with depression, combining medication and CBT was optimal, and CBT alone was comparable to placebo in individuals with depression (TADS, 2004). However, in a secondary TADS study in which only participants from the TADS study who were diagnosed with ADHD were evaluated, CBT alone also provided significant improvements to depression symptoms among this subset of participants, not merely the combined treatment alone (Kratochvil, 2009). Results such as these suggest that CBT, even without antidepressant medication, may benefit clients with ADHD and depression. Moreover, in cases where it is prudent to treat ADHD symptoms first (e.g., medication, behavioral therapy) before introducing depression medication, these findings suggest CBT may assist in alleviating depression symptoms.

One potential utility of CBT as a treatment approach for treating ADHD, regardless of clinically significant comorbid psychopathology, is that it may also be preventative against depression and increase resilience to symptoms of low mood, especially since depression typically emerges later in life than ADHD (Knouse et al., 2013a, b; Luthar & Cicchetti, 2000; Oddo et al., 2018). When provided early, even without the presence of depressed mood, CBT to teach coping skills to individuals with ADHD may reduce those cognitive mechanisms found in some research to fully mediate the relationship between ADHD and depression (Knouse et al., 2013a, b). Namely, dysfunctional attitudes, ruminative thinking, and cognitive and behavioral avoidance are noted as particularly salient mediators of this relationship and are constructs directly addressed in CBT treatment (Knouse et al., 2013a, b; Oddo et al., 2018). Additionally, CBT places a large emphasis on improving emotion regulation skills by helping individuals understand the interplay between thoughts, feelings, and behaviors and find ways to respond adaptively, even in emotionally charged situations, which is a difficulty those with depression and ADHD may experience (Meinzer et al., 2014). By adding supplementary emotion regulation skills to a typical course of CBT, the effects of the interventions may also improve further across a wide array of diagnoses (Berking et al., 2008). Addressing these mechanisms by providing adaptive coping and emotion regulation skills to help prevent the development of negative self-schemas and poor emotional control at an early age may be a critical avenue of treatment.

The Behaviorally Enhancing Adolescents' Mood (BEAM) program is a tailored CBT preventive intervention that aims to address depression among adolescents with ADHD. The BEAM program is a promising psychosocial intervention that aims to address the mechanisms between ADHD and depression (i.e., reward responsiveness, emotion regulation, and family support) to reduce current depression symptoms and prevent escalation to major depression disorder (Meinzer et al., 2018). BEAM draws from behavioral activation (BA), an empirically supported treatment for depression (Dimidjian et al., 2011; Hopko et al., 2003; McCauley et al., 2011), and has youth identify and schedule meaningful activities to promote sustained engagement in their environment and assist with executive functioning tasks such as organization and planning. Participating in these value-driven activities helps increase the frequency and quality of rewarding experiences for youth, reinforces behaviors that buffer against depression, and promotes sustained investment in utilizing executive skills. Pilot studies of the BEAM program have been conducted both in a research clinic (Meinzer et al., 2018) and within a high school, where it was delivered by school mental health providers (Meinzer et al., 2022). Results of these studies suggest that BEAM was feasible to implement, was well-received by parents and youth, and resulted in changes in depression symptoms and target mechanisms (Meinzer et al., 2018, 2022).

14.6.3 Academic and ADHD-Focused Interventions

Researchers often recommend academic accommodations in schools and intervention academic skills programs as potential avenues for addressing mood symptoms. The Demoralization Theory, as previously discussed, posits that negative academic and social impairment associated with ADHD can lead to feelings and cognitive schemas of failure and low self-efficacy (i.e., demoralization). Therefore, treating academic difficulties may have downstream effects on depression. In a study by Barney et al. (2022), a high-intensity academic skills intervention was associated with significant decreases in depression symptoms in adolescents with ADHD. These effects were not seen in low-intensity skills training, suggesting that the intensity of intervention should be considered to improve mood.

In addition to academic skills-based interventions, the provision of academic accommodations (i.e., tutoring, computer assistance, instructional modifications, and testing accommodations) may contribute to improvements in academics and subsequent improvements in mood. However, little empirical evidence has been shown for the efficacy of typical accommodations on academic or mental health outcomes among children, adolescents, and young adults with ADHD (Tufty et al., under review). Empirically supported (i.e., behavioral) approaches in classroom settings are very effective at improving the school functioning of youth with ADHD, as are some strategies such as peer tutoring and modifying tasks (Dupaul & Eckert, 2006; Dupaul & Weyandt, 2006). However, depression symptoms are typically not evaluated as outcomes of academic and school-delivered treatments for youth with ADHD (Dupaul & Weyandt, 2006). Notably, in the Barney et al. (2022) study, high-intensity intervention was necessary to observe significant mood symptom reduction, which may not always be feasible for schools and families, though it does suggest that previous studies may not have provided the intensity of treatment needed to see these improvements in mood.

Some of these academic interventions often hinge on the potential mood benefits of reducing demoralization and stressful experiences in schools (Daviss, 2008). However, some research suggests that the relationship between ADHD and depression is driven primarily by cognitive distortions and behavioral and emotional avoidance in the face of stressors rather than the number and types of stressors themselves (Knouse et al., 2013a, b; Oddo et al., 2018). Therefore, though improving academic skills and experiences in the academic environment is meaningful in addressing academic and attentional outcomes in ADHD, addressing the cognitive-behavioral concerns and coping skills of those with ADHD may better address the impact of negative academic experiences on mood, namely if high-intensity academic skills training is not available (Knouse et al., 2013a, b; Oddo et al., 2018).

One avenue for treatment that has been adopted in college settings and draws from this research literature on the value of behavioral training, cognitive approaches, and academic support is the Students Understanding College Choices: Encouraging and Executing Decisions for Success (SUCCEEDS) program. SUCCEEDS pairs academic coaching with similar BA techniques to those used in BEAM to help college students with ADHD identify meaningful areas in their lives and engage in activities that are rewarding and help meet academic and personal goals.

SUCCEEDS addresses common cognitive and behavioral barriers to effective decision-making and functioning in college and provides these students with skills around planning, decision-making, and reducing behavioral avoidance (Meinzer et al., 2021a, b; Vasko et al., 2020). To date, few intervention programs incorporate psychosocial and academic treatment aspects to provide a comprehensive, skills-based wrap-around program for college students.

14.7 Parental Interventions

Given that research has pointed to parental support and behavior management as mediators of the relationship between ADHD and depression, intervening on these targets may impact depression symptoms in youth with ADHD. (Danforth et al., 1991; Humphreys et al., 2013; Ostrander & Herman, 2006; Pojanapotha et al., 2021). Parent training interventions are widely studied with younger children and demonstrate strong empirical support for addressing ADHD symptoms (Chronis et al., 2004; Young & Amarasinghe, 2010; Zwi et al., 2011). Further, parent-child relationship quality and parenting practices are predictive of depression symptoms among youth, especially when parents experience depression symptoms themselves (Garber et al., 1997; Kuckertz et al., 2018; McLeod et al., 2007). Thus, addressing parenting practices may be a buffer against youth depression, namely among youth whose caregivers are experiencing more stress (Biondic et al., 2019; Theule et al., 2013).

Additionally, interventions that target parental mental health may reduce the risk of depression among youth with ADHD. Parental depression symptoms are a strong predictor of children developing depression themselves, which is concerning given that approximately half of parents of children with ADHD experience depression (Meinzer & Chronis-Tuscano, 2017; Weissman et al., 2006). The integrated parenting intervention for ADHD (IPI-A) (Chronis-Tuscano et al., 2013) is one such approach that provides a group-based parenting intervention for caregivers of youth with ADHD; it teaches both child behavior management skills and provides CBT to parents to address their own depression symptoms. Results found that parents' depression was reduced and children experienced better behavioral and functional outcomes in those who were enrolled in the IPI-A. Thus, reducing maternal depression in the context of behavioral parenting interventions could mitigate the risk of depression in youth with ADHD.

In sum, the treatment literature on ADHD has often acknowledged the connection between ADHD and depression. In some cases, studies have even looked at depression symptom changes as a secondary outcome of ADHD treatment. However, treatments targeting clinically significant depression and ADHD simultaneously are rare. The literature indicates that our current medications for ADHD and depression are both effective for individuals with comorbid ADHD and depression and that these medications can be used concomitantly. In addition, CBT may be helpful in the treatment and prevention of depression in those with ADHD.

14.8 Case Study

Amira is a 21-year-old Middle Eastern woman born in the United States and a current college student. Amira reported a history of difficulties with schoolwork throughout her life as well as strained relationships with her parents. Her teachers and parents described Amira as generally well-behaved and very smart but also observed she had difficulties with completing tasks, distractibility, and producing quality work. Her pediatrician recommended testing for ADHD; however, Amira was never assessed for the disorder. This decision was informed by her ability to mitigate many of the negative consequences associated with her executive functioning problems, as well as her family's negative, stigmatized beliefs about ADHD and medications for the disorder. She noted that most arguments with her parents were related to her academic performance and her fears that she would be unable to pursue a rigorous college major and career.

Amira cited periods of low mood and anxiety in high school but stated that these symptoms worsened in college. She seldom attended her classes because she reported feeling too fatigued and emotionally overwhelmed by the organizational demands of a college course. For example, she shared that her tendency to complete assignments at the last moment ultimately resulted in incomplete assignments. Additionally, Amira described a history of pursuing short-term rewards, often with negative consequences, such as staying up late playing video games and binge-watching TV shows, as well as forgoing hobbies and quality time with family and friends. Amira failed the majority of her courses during her first year and decided to withdraw from her university due to pronounced depression symptoms and a marked difficulty associated with keeping up with the increased academic demands. During this time, Amira reported experiencing increased social withdrawal from friends and arguments with her parents.

With eventual support from her parents, Amira sought a formal, comprehensive psychiatric assessment to inform her treatment options. The assessment revealed that she exhibited above-average cognitive abilities and academic skills, as well as significant impairments in executive functioning, mood, and anxiety. Amira was diagnosed with ADHD, an inattentive type, and major depressive disorder. Following her assessment, Amira decided to begin a psychosocial therapeutic approach to address her difficulties, acknowledging that she could supplement with pharmacological treatment should that be warranted. Amira enrolled in therapy with a psychologist who promoted evidence-based interventions to comprehensively address her ADHD and depression. To treat her depression symptoms, her therapist used a combination of cognitive and behavioral techniques to address her negative automatic thoughts (e.g., “If I don’t do well on this test, I’ll get a bad grade and will have to drop out of school again”) and core beliefs (e.g., “I am stupid,” “I am a failure”). Amira began therapy with strong, negative beliefs about her worth and her intelligence due to her history of poor academic performance. Acknowledging the strong cognitive abilities and academic potential indicated by her assessment helped Amira examine the veracity of her negative beliefs. Her therapist was able to build upon the psychoeducation provided by the assessment clinician to help Amira create a more balanced view of herself and how her functioning has been impacted by both her depression and ADHD.

Behavioral activation (BA) was also used to help Amira increase her engagement in meaningful, value-driven activities. She learned her sleep disturbances, leading to difficulties waking up and attending classes, stemmed from a pattern of taking naps to avoid schoolwork. She gained insight into her maladaptive behaviors to cope with her low mood and academic disappointments, such as becoming socially withdrawn, canceling plans, and spending the majority of her leisure time playing video games in isolation. BA helped Amira persist in her participation in meaningful, value-driven activities such as hobbies and quality time with family and friends and reduce behavioral avoidance when her mood was low.

In addition to her work with her psychologist, Amira was connected to an academic skills program through her school that helped her improve her time management and task prioritization skills, develop effective study skills, and reduce her avoidance of schoolwork. This improvement in her academic skills improved her confidence and self-efficacy, which in turn contributed to a decrease in her depression symptoms.

Amira was able to implement CBT practices into her daily life, regularly practice the executive skills introduced during her coaching sessions, and receive continued assistance and support from her parents and her romantic partner to earn A’s and B’s during her first semester. In subsequent semesters, she continued to maintain a high GPA, was accepted to a prestigious internship during her sophomore year, and advanced into a specialized track for her major during her junior year. She attributed these successes to her improved mood, restructured beliefs about her abilities in school, increased social support and communication with family, her partner, and academic mentors, and increased self-efficacy around coping with distress.

14.9 Future Directions

Despite the strides made in increasing research regarding ADHD and comorbid depression over the last two decades, there is a need for continued research in this area. First, future research should continue examining the risk and protective factors for the emergence of depression among individuals with ADHD. Though ADHD is associated with a risk for depression, not all individuals with ADHD will experience a major depressive episode; at least 50% of individuals do not report a history of depression (Meinzer et al., 2013). Therefore, it is crucial that research identify which individuals with ADHD may be at greatest risk for depression to better allocate resources. Though previous work has begun to identify potential moderators (e.g., cognitive thinking styles), additional work is necessary in this area. For instance, race/ethnicity is an important construct that has been largely unexplored, with the majority of the work examining ADHD and depression being conducted in samples comprised of predominantly Caucasian individuals. There may be environmental and systemic factors (e.g., discrimination, socioeconomic position, stressful life events; Bailey et al., 2019) associated with race/ethnicity that exacerbate the relationship between ADHD and depression. Therefore, future work needs to ensure more diverse samples within ADHD-depression research to better understand how race/ethnicity and associated constructs might amplify the risk for depression among those with ADHD. In addition to examining risk factors, research should also continue to examine protective factors (e.g., community-level variables, social supports) that may help mitigate the risk of depression among individuals with ADHD.

Though past work has explored mediators of the relationship between ADHD and depression (e.g., reward processing, emotion regulation capabilities, academic and social impairment, aspects of peer and family functioning), further examination of potential mediators (e.g., sleep quality, trauma exposure, executive functioning) is necessary to inform prevention and intervention efforts. Additionally, the majority of research examining parenting constructs within this context has been largely focused on mothers and their children (e.g., Humphreys et al., 2013; Meinzer et al., 2021a, b). Future work should examine paternal relationship quality and fathers' parenting practices with their children. Furthermore, this research should incorporate alternative methodologies to examine existing and potential mediators. The vast majority of research has utilized self-report or parent-report questionnaires. Future work should utilize approaches such as observational methods, computerized tasks, and neuropsychological tests to measure proposed mediators (Seymour & Miller, 2017). Uncovering these additional mechanisms could help to better understand the pathway from ADHD to depression and inform the expansion of tailored treatment and prevention efforts.

Research on the moderators and mediators of ADHD and depression is crucial in informing *who* to provide with depression prevention programming and *how* best to intervene. Existing programs like BEAM (Meinzer et al., 2018, 2022) target reward responsivity, emotion regulation, and family support. Continued treatment development research should seek to incorporate mechanistic research to target the variables responsible for the development of depression among individuals with ADHD. Additionally, given that persistent ADHD symptoms and ADHD-related impairment (e.g., academic and social difficulties) may be at least partially responsible for the emergence of depressive episodes, future research should examine the effect of continued treatment for ADHD throughout adolescence and adulthood on subsequent depression symptoms. Efforts should also be made to infuse depression prevention content into existing evidence-based interventions for treating ADHD.

Regardless of whether this mental health programming takes the form of prevention or intervention efforts, there is a critical need to increase access to this care, especially for underrepresented groups. There needs to be increased care for ADHD and depression comorbidity in settings that reduce barriers to care and reduce stigma (e.g., schools, primary care; Barrett & Pahl, 2012; Calear & Christensen, 2010; Paternite, 2005). Incorporation of interventions for ADHD and even comorbid ADHD and depression has been successfully integrated into schools (e.g., Evans et al., 2014; Meinzer et al., 2022) and primary care (Power et al., 2013). In addition to implementing this care within community settings, telehealth may further remove logistical barriers for families (e.g., transportation, childcare, lack of evidence-based treatments for ADHD within driving distance). Programs such as supporting teens academic needs daily (STAND; 2017) and Behaviorally Enhancing Adolescents' Mood (BEAM (Meinzer et al., 2022) have successfully used online methodology to treat patients in individual and group settings. Additionally, technology-assisted, self-directed programming has been developed that is effective for treating depression and has even been disseminated within primary care settings (e.g., CATCH-IT; Gladstone et al., 2018). Similar prevention efforts should be tested within the ADHD population.

Finally, within the last decade, there has been an increase in the amount of research given to other mood-related diagnoses (e.g., sluggish cognitive tempo [SCT], disruptive mood dysregulation disorder [DMDD]) and their comorbidity with ADHD and its associated impairment (e.g., Barkley, 2013; Uran & Kılıç, 2020; Leikauf & Solanto, 2017; Mulraney et al., 2016). Though SCT and DMDD were not the focus of this chapter, it is important to note that the relationship between ADHD and these constructs shares apparent similarities with ADHD-depression comorbidity. Thus, future work needs to disentangle how comorbid ADHD and depression are distinct (or similar) to DMDD and SCT.

In sum, though there have been significant advancements in the diagnosis, understanding, and treatment/prevention of comorbid ADHD and depression, researchers need to better understand *which* individuals with ADHD are at greatest risk for depression and how to best identify this risk early. Additionally, research needs to continue examining the mechanisms of ADHD and depression to better tailor depression interventions for this population. These interventions need to be subsequently disseminated into the settings in which children, adolescents, and adults receive routine care.

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15 Comorbid Diagnosis of ASD and ADHD: Assessment and Treatment Considerations

Celeste Tevis

15.1 Diagnostic Criteria

15.1.1 ASD

Autism spectrum disorder (ASD) is characterized as a neurodevelopmental disorder with persistent impairments in social communication and social interaction, as well as restricted interests and repetitive behaviors (American Psychiatric Association, 2013). In the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)*, an individual must exhibit deficits in the following areas of social communication and social interaction in various settings: social-emotional reciprocity, nonverbal communication behaviors used to socially interact with others, and developing, maintaining, and understanding relationships (Criterion A). Additionally, an individual must demonstrate at least two out of the following four categories of restricted interests and repetitive patterns of behavior: stereotyped or repetitive motor movements, use of objects, or speech; insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior; highly restricted, fixated interests that are abnormal in intensity or focus; and hyper-or-hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment (Criterion B). These symptoms must be present early in development (Criterion C); cause clinically significant difficulties in occupational, social, or related areas of functioning (Criterion D); and not be better accounted for by an intellectual disability or mental health condition (Criterion E).

In an attempt to take a more dimensional approach to psychopathology, the DSM-5 introduced severity specifiers to the diagnostic criteria for ASD. Severity is based on the amount of support required for the core symptoms of ASD (Lord & Bishop, 2015). The three severity specifiers are as follows: level 1 "requiring support," level 2 "requiring substantial support," and level 3 "requiring very substantial support." Both the impairments in social communication and restricted interests and repetitive behaviors should be separately assigned a severity level (APA, 2013). In addition to severity specifiers, the DSM-5 acknowledges variability among individuals with respect to non-core symptoms of ASD. Clinicians should also specify whether an intellectual disability, language impairment, associated medical or genetic condition, environmental factors, neurodevelopmental, mental, or behavioral diagnoses accompany the ASD diagnosis (APA, 2013).

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15.1.2 ADHD

Attention-deficit hyperactivity disorder (ADHD) is also a neurodevelopmental disorder in the DSM-5, characterized by executive functioning difficulties (e.g., impairments in working memory and sustained attention) and disinhibited behavioral patterns (May et al., 2018). ADHD consists of a persistent pattern of inattention and/or hyperactivity-impulsivity symptoms that impact functioning and development of an individual. To meet DSM-5 diagnostic criteria for ADHD, a child must have a minimum of six symptoms of inattention and/or hyperactivity-impulsivity that have persisted for 6 months or longer (Criterion A). The symptoms of inattention and/or hyperactivity-impulsivity should be present before the age of 12 (Criterion B) and across multiple settings in which the child interacts (Criterion C). Finally, the symptoms should clearly reduce the individual's quality of social, academic, or occupational functioning (Criterion D) and should not be better accounted for by the presence of another mental health condition (Criterion E) (APA, 2013). Revisions to DSM-5 indicated changes to Criterion E, such that ASD is no longer considered an exclusionary diagnosis (Epstein & Loren, 2013).

Additionally, DSM-5 identifies three presentations that can be specified: ADHD combined presentation (ADHD-C), ADHD predominately inattentive presentation (ADHD-I), and ADHD predominantly hyperactive/impulsive presentation (ADHD-H). ADHD-C should be specified if the child exhibits at least six symptoms of inattention and hyperactivity-impulsivity within the past 6 months; ADHD-I should be specified if at least six symptoms of inattention are demonstrated within the past 6 months but fewer than six hyperactivity-impulsivity symptoms; ADHD-H should be specified if at least six symptoms of hyperactivity-impulsivity were exhibited within the past 6 months but fewer than six inattention symptoms (APA, 2013). Modifiers were also added to the DSM-5 to allow for the severity level (i.e., mild, moderate, severe) of the disorder to be specified. A mild severity level is reserved for individuals who present with minimal to no symptoms beyond those that are required to meet diagnostic criteria. A severe severity level is designated when several symptoms beyond those required to meet diagnostic criteria are present (APA, 2013; Epstein & Loren, 2013).

15.2 Comorbid ASD and ADHD

15.2.1 Prevalence Rates and Clinical Profile

The prevalence rates of both ASD and ADHD have steadily increased over the past decade. Prior to the DSM-5, clinicians could not assign diagnoses of ASD and ADHD together, as it was presumed that symptoms of inattention and hyperactivity were accompanying symptoms of ASD; however, it is currently understood that ADHD and ASD frequently co-occur (Zablotsky et al., 2020; Antshel & Russo, 2019). Large epidemiological studies previously found that approximately 12.5% of individuals diagnosed with ADHD also were diagnosed with comorbid ASD. A significant difference in sex was found, such that males with ADHD were approximately at two times greater risk for ASD compared to their female counterparts with ADHD (Jensen & Steinhausen, 2015; Zablotsky et al., 2020). Prevalence rates of ADHD are reportedly much higher among children diagnosed with ASD, as ADHD is the most commonly reported comorbidity among children with ASD. Approximately 30–80% of children with ASD also have an ADHD diagnosis (Belardinelli et al., 2016). Rau et al. (2020) further examined prevalence rates of ADHD by presentation in a sample of individuals with ASD and found that ADHD-C (76.8%) presentation comprised the largest portion of ADHD diagnoses, followed by ADHD-I (19.7%) and ADHD-H (0.02%). Even among individuals with ASD that do not meet DSM-5 diagnostic criteria for ADHD, symptoms of ADHD were found to be elevated and vice versa (Antshel & Russo, 2019). The frequent comorbidity of these conditions can make diagnosis and treatment exceedingly difficult.

15.2.2 Shared Risk Factors

15.2.2.1 Genetic and Biological

While there are important differences in the diagnostic criteria of ASD and ADHD, impacted individuals share impairments in similar areas of functioning. Previously, researchers have suggested that these neurodevelopmental disorders may share common etiological risk factors, which may explain the high rates of comorbidity among the conditions. One key risk factor is a shared genetic basis between ASD and ADHD. The presence of a shared genetic link between ADHD and ASD has been supported by several familial and twin studies. Two early familial studies using the IMAGE cohort (International Multicenter ADHD Genetic study) investigated the prevalence rates and severity of ASD among probands with ADHD and their siblings (Leitner, 2014; Rommelse et al., 2010). In both of these studies, researchers found higher autism symptomology among the male and female probands and their siblings compared to the typically developing control group (Mulligan et al., 2009; Nijmeijer et al., 2008).

Two recent familial studies investigated the risk of ADHD among probands with ASD and their siblings. Septier et al. (2019) evaluated the risk of ADHD among 1245 participants enrolled in the study, a group of relatives of individuals with ASD (ASD−) and a group of relatives of individuals with comorbid ADHD and ASD (ASD+). After adjusting for socioeconomic factors (i.e., sex, age, and intellectual quotient), researchers found the risk of ADHD to be higher among relatives of the ASD+ group compared to the relatives of the ASD− group. In a second study by Ghirardi et al. (2018), the association between ASD and ADHD was tested in 1,899,654 individuals ($N = 28{,}468$ ASD; $N = 82{,}398$ ADHD; $N = 13{,}793$ comorbid) born in Sweden between 1987 and 2006 and across various types of relatives. Individuals with ASD were found to be at higher risk for developing ADHD compared to individuals without ASD. Additionally, relatives of those with ASD were more likely to be diagnosed with ADHD compared to relatives of individuals without ASD. More specifically, siblings of children with ASD were found to have a 3.7 times higher likelihood of being diagnosed with ADHD than siblings of children without ASD.

Previously completed twin studies have indicated that there are genetic correlations between ASD and ADHD symptoms, as measured by parent and teacher self-report measures, ranging between 0.50 and 0.72; nearly 50–72% of the variation in ADHD and ASD symptoms may be related to genetic factors (Reiersen et al., 2007; Rommelse et al., 2010). The association between ASD and ADHD symptoms is stronger among monozygotic twins (genetically identical) than dizygotic twins (full siblings); monozygotic twins each diagnosed with ASD are at a much higher risk of meeting diagnostic criteria for ADHD compared to dizygotic twins (Ghirardi et al., 2018). These findings suggest that ASD symptomology is heritable in families impacted by ADHD, though no specific gene variations linking the disorders have been identified at this time (Rommelse et al., 2010; Antshel & Russo, 2019).

In anatomical brain studies evaluating individuals with ASD, researchers have found greater white matter volume in various parts of the brain, such as the cerebellum, caudate, and globus palladium. Prior neuroimaging research investigated the relationship between symptom severity of both ASD and ADHD and gray matter volume and found that symptom severity for each disorder correlated with gray matter in the left frontal gyrus. Neuroimaging also indicated a smaller corpus callosum in both ASD and ADHD (Leitner, 2014).

15.2.2.2 Environmental

While shared genetic underpinnings of ASD and ADHD have been supported by numerous studies, environmental risk factors may also be shared by ASD and ADHD. Relative to the number of studies that have evaluated genetic risk factors, non-biological risk factors, with the exception of gender-based differences in prevalence, have rarely been studied (Taurines et al., 2012; Carrascosa-Romero & De Cabo-De La Vega, 2015). Recent population-based studies reported increased rates of inattention and ASD symptoms among children and adults born preterm (i.e., below 26 weeks gestation) (Johnson et al., 2010; Halmoy et al., 2011). Additionally, pregnancy-related risk factors, such as maternal diabetes, pre-eclampsia, toxic exposures/use of valproic acid, and infections, may increase the risk of ASD and ADHD development throughout the lifespan; however, several of these above-mentioned environmental risk factors are not well-replicated in research currently, and additional population-based studies should be completed in the future (Taurines et al., 2012; Carrascosa-Romero & De Cabo-De La Vega, 2015).

15.2.3 Symptom Impact and Overlap

Since the publication of the DSM-5, ASD and ADHD diagnoses are no longer mutually exclusive (Epstein & Loren, 2013). Both of these neurodevelopmental disorders typically onset during childhood and are characterized based on behavioral symptoms. While the core diagnostic criteria of ASD and ADHD do not overtly overlap, both disorders typically include impairments in communication with peers, socialization, and varying degrees of attention difficulties, hyperactivity, or impulsivity (Leitner, 2014; Carrascosa-Romero & De Cabo-De La Vega, 2015). The co-occurrence of ASD and ADHD may impact daily functioning beyond that of either diagnosis in isolation (Hatch et al., 2023). Based on teacher and caregiver reports, children with comorbid ASD and ADHD experience greater difficulties with adaptive skills, socialization, and cognitive functioning (Rao & Landa, 2014). Children with higher ASD symptom severity and ADHD have also been found to have increased conduct problems and emotional difficulties (Hatch et al., 2023). Additionally, these co-occurring conditions may be less responsive to treatments intended for either condition (Leitner, 2014). These research findings support a thorough assessment of autism symptomology in ADHD to better inform the provision of intervention.

15.2.3.1 Attention/Executive Functioning

Executive functioning is a term used to describe various aspects of attention, including the ability to switch attention between stimuli, sustain attention, inhibit responses, and utilize working memory (May et al., 2018; Antshel & Russo, 2019). Research evaluating executive functioning in both conditions reported impairments compared to typically developing age-and-IQ-matched participants, though the particular executive functioning deficits may differ slightly for each condition (Antshel & Russo, 2019). Based on prior research, individuals with ADHD may experience more difficulties with inhibition (i.e., restraining a response) and problem-solving, while those with ASD may exhibit difficulties with cognitive flexibility and switching attention between stimuli (Happe et al., 2006). Among children with ASD, performance on executive functioning tasks is positively correlated with social communication skills, negatively associated with hyperactivity, and generally improves with age; however, these findings were not supported among children with ADHD. Researchers examining executive functioning in individuals with comorbid ASD and ADHD indicated that those with both conditions exhibit more impairment with inhibiting responses than ADHD alone. Similarly, those with comorbid ASD and ADHD exhibited more difficulty with planning and cognitive flexibility than those only diagnosed with ASD (Antshel & Russo, 2019).

15.2.3.2 Social Cognition and Social Interaction

Persistent impairments in social interaction and communication are characteristic of ASD and are required by the DSM-5 to meet the criteria for the diagnosis. While impairments in social functioning are not necessary for an ADHD diagnosis, children with ADHD often experience significant social difficulties. Children with ADHD are more likely to be rejected by peers and have fewer friends than their typically developing peers. Core hyperactivity/impulsivity symptoms, including: "excessive talking," "blurting out answers," "difficulty waiting their turn," and "interrupting or intruding on others," may result in upsetting peers, impeding upon participation in extracurricular activities, and peer avoidance. Further, psychiatric comorbidities, such as mood disorders, anxiety, and conduct disorder among children with ADHD, have been found to exacerbate social difficulties (Antshel & Russo, 2019; Leitner, 2014). Likewise, children with ASD often struggle to make and maintain friendships, resulting in fewer reciprocal relationships. Although similar social difficulties are observed in both diagnoses, the profile of social skill impairments often differs among those with ADHD and ASD. Children with ASD frequently lack knowledge and understanding of social cues and interactions, such that they exhibit a lack of emotional reciprocity, reduced sharing of emotions/affect, and decreased social interaction (APA, 2013; Antshel & Russo, 2019). Social difficulties among those with ASD usually result from an absence of positive social behaviors, including eye contact, use and understanding of gestures, and social initiations. Alternatively, individuals with ADHD are more likely to have social knowledge but demonstrate difficulties with social performance around peers. The presence of negative social behaviors, such as excessive talking or interrupting peers during conversations, is likely to impact social functioning among those with ADHD (Antshel & Russo, 2019).

15.2.4 Diagnostic Assessment Process

15.2.4.1 Assessment Considerations

No single measure can be used to diagnose or distinguish between ASD and ADHD, as they are both diagnoses made based on the presence of observable behavioral symptoms (May et al., 2018; Rommelse et al., 2018). It is crucial for clinicians to assess the frequency, intensity, duration, and impact of the presenting symptoms to determine whether or not they are clinically significant. Assessing ADHD symptoms can be particularly challenging as some symptoms of inattention and hyperactivity/impulsivity can be exhibited by all children, especially during toddlerhood and early childhood. Best practice guidelines recommend that clinicians adhere to the following standards to improve the reliability of the diagnoses: only make diagnoses when all DSM criteria are fulfilled, use standardized diagnostic measures and behavior rating scales, obtain information from multiple sources (e.g., caregivers, teachers), and assess for any comorbid developmental, medical, and/or psychiatric conditions. The main components of a comprehensive diagnostic evaluation necessary to differentially diagnose ASD and ADHD are described below.

Developmental History and Caregiver Interview Conducting a caregiver interview is a crucial component in a comprehensive diagnostic evaluation. The caregiver interview should aim to acquire information regarding developmental, medical, and psychiatric history. Regarding developmental history, clinicians should obtain information about pregnancy and delivery, age of speech (i.e., first words, first phrase speech) and motor (i.e., crawling, walking) milestones, skill regression history, and age and type of first caregiver concerns. When discussing medical history, the clinician should review medical records with caregivers and consider prior diagnoses, current or previous therapeutic services received, medical problems, hearing or vision concerns, and sleep and feeding difficulties. Finally, a structured or semi-structured clinical symptom interview should be conducted with caregivers and the child receiving the diagnostic evaluation. During clinical evaluations with older children or adolescents, self-reports are particularly important, as caregivers and teachers may experience difficulty observing symptoms of inattention (May et al., 2018).

During the clinical interview, the clinician should acquire a detailed history of the presenting inattention, hyperactivity, and impulsivity symptoms, as well as the intensity, frequency, duration, and functional impairment of the symptoms. Clinicians should also inquire about the child or adolescent's broader psychiatric functioning, family history of mental health difficulties and neurodevelopmental disorders, current strengths, and desired goals following the diagnostic evaluation (May et al., 2018).

Behavior Rating Scales Broadband and narrowband rating scales should be used to supplement clinical interviews during a diagnostic evaluation. Broadband rating scales, such as the Achenbach Child Behavior Checklist, Behavioral Assessment System for Children (BASC), can be used to assess a child's clinical profile. Multiple informants, including caregivers and teachers, should complete rating scales to assist with differential diagnoses of ASD and ADHD, as well as any additional comorbid diagnoses. When considering an ADHD diagnosis, it is essential to obtain rating scales from multiple informants to determine the symptom presentation across multiple contexts, as well as the functional impairment that the symptoms may cause across these contexts. If informants do not report ADHD symptomology across multiple contexts, then an alternative diagnosis may be more appropriate; however, discrepancy between rating scale informants is not uncommon and may reflect differences in symptoms across locations, time of day, and other contexts. Additional information from teachers, particularly through school records (e.g., academic performance across subjects, disciplinary records) and teacher interviews, can provide qualitative information about ADHD symptoms and the impairments they may cause across students (May et al., 2018).

Cognitive Assessment Cognitive assessments may not be necessary during each ADHD assessment, particularly when there are no concerns of co-occurring ASD; however, cognitive assessments should be consistently included in diagnostic evaluations when intellectual functioning may be of concern (Hatch et al., 2021). IQ tests, like the Wechsler Intelligence Scale for Children (WISC), allow clinicians to observe relative strengths and weaknesses among cognitive tasks that children with suspected ADHD may exhibit. For example, children with ADHD typically perform poorly on rote memory tasks, like Digit Span, and tasks that require high processing speed to quickly and accurately discriminate between visual information, like Coding. Computerized tests of attention can be administered in addition to IQ tests to directly test sustained attention and vigilance (see Sect. 15.2.4.2 below for further details) (Gualtieri & Johnson, 2005).

Behavioral Observations Psychologists should observe and record any behaviors that may be indicative of ADHD or ASD. Tools that directly assess autism symptomology, such as the Autism Diagnostic Observation Schedule, 2nd Edition (ADOS-2; Lord et al., 2012), should be utilized as they allow clinicians to probe for and directly evaluate communication skills, social interaction, imaginative play, and restricted interests/repetitive behaviors in children suspected of having ASD. There are no single gold-standard, validated psychological tests required to make a diagnosis for ADHD. Rather, assessments of ADHD should involve a combination of interviews from several informants, standardized behavior rating scales, and behavior observations in various settings. Clinicians should not be solely reliant upon behavioral observations made in a one-on-one setting to make a diagnosis of ADHD, as symptoms are more likely to occur in naturalistic settings. Children with ADHD can frequently regulate symptoms of inattention and hyperactivity/impulsivity for short periods of time, particularly in new environments or with unfamiliar people (May et al., 2018).

15.2.4.2 Assessment Tools

Several diagnostic tools can be used to aid in assigning ASD and/or ADHD diagnoses. Several narrowband ASD-specific measures (i.e., ADOS-2, CARS-2, ADI-R, SRS-2, CASD), ADHD-specific measures (i.e., ADHD-RS-5, Conners-3, VADRS), and broadband psychiatric measures (i.e., BASC-3, CBCL) will be discussed. While other chapters in this text will provide a thorough review of ADHD assessment tools and their psychometric properties, this chapter provides a discussion of each of these assessment tools and their ability to differentiate between ASD and ADHD diagnoses (see Table 15.1).

Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012) The ADOS-2 is a standardized, semi-structured observational tool designed to assess ASD concerns across four domains: social communication, social interaction, repetitive behaviors and restricted interests, and play/imagination skills (McCrimmon & Rostad, 2013). The ADOS-2- consists of five separate modules, including the Toddler Module and Modules 1–4, which assess children aged 12 months through adulthood. The

Table 15.1 Assessment tools for differential diagnoses of ASD and ADHD

Measure	Type	Age	Administration time	Supporting research
Autism Diagnostic Observation Schedule—Second Edition (ADOS-2; Lord et al., 2012)	ASD specific Observational tool	12 months +	40–60 min	Kamp-Becker et al. (2013) Grzadzinski et al. (2016)
Childhood Autism Rating Scale—Second Edition (CARS-2; Schopler et al., 2010)	ASD specific Observational tool	2 years+	30–45 min	Mayes et al. (2012)
Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003)	ASD specific Parent/caregiver Structured interview	Mental age of 2 years+	1.5–2 h	Grzadzinski et al. (2016)
Social Responsiveness Scale, Second Edition (SRS-2).	ASD specific Informant-report rating scale	2 years, 6 months +	15–30 min	Moul et al. (2015) Factor et al. (2017)
The Checklist for Autism Spectrum Disorder Symptoms (CASD; Mayes, 2012).	ASD specific Semi-structured caregiver interview	1–17 years	10–15 min	Mayes et al. (2009) Mayes et al. (2012)
ADHD Rating Scale—5 for Children and Adolescents (ADHD-RS-5; Dupaul et al., 2016).	ADHD specific Informant-report rating scale	5–17 years	5 min	Hattori et al. (2006) Yerys et al. (2017)
The Conners Third Edition (Conners-3).	ADHD specific Informant report rating scale	6–18 years	20 min (long form) 10 min (short form)	Ehlers et al. (1999)
The Vanderbilt ADHD Diagnostic Rating Scales (VADRS).	ADHD specific Informant-report rating scale	6–12 years	10 min	No current research
The Behavior Assessment System for Children, Third Edition (BASC-3; Reynolds & Kamphaus, 2015).	Broad psychiatric assessment tool Informant-report rating scale	2–21 years	10–20 min	Yerys et al. (2009) Zhou et al. (2020)
The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001).	Broad psychiatric assessment tool Informant-report rating scale	1.5–18 years	10–15 min	Holtmann et al. (2007)

clinician administers a series of activities, then subsequently rates behaviors on several coded items related to social affect and restricted and repetitive behavior (RRB). Clinicians select modules for diagnostic purposes based on the chronological age and the level of expressive language exhibited by the client (McCrimmon & Rostad, 2013). The ADOS-2 is designed to be administered in about 40–60 min by professionals with advanced training in the administration and interpretation of the measure (Committee on Psychological Testing, 2015).

While extensive research evaluated the psychometric properties of the ADOS-2, the validation sample did not include individuals with ADHD, as ADHD and ASD could not be diagnosed together prior to the DSM-5. As a result, the discriminant validity was not directly tested in those with ADHD (Antshel & Russo, 2019). Since then, researchers have indicated that between 7% and 21% of those with ADHD meet or exceed cutoff criteria for ASD on the ADOS using both the original and revised algorithms (Kamp-Becker et al., 2013; Grzadzinski et al., 2016). Only four items on the ADOS-2 adequately differentiated ADHD and ASD (Grzadzinski et al., 2016).

Childhood Autism Rating Scale, Second Edition (CARS-2; Schopler et al., 2010) The CARS-2 is a clinician-rated measure that consists of 15 items that assess the following domains along a 4-point rating scale: relating to people, imitation, emotional response, body use, object use, adaptation to change, visual response, listening response, taste, smell, and touch response/use, fear or nervousness, verbal communication, nonverbal communication, activity level, and consistency of intellectual response, and general impressions. The CARS-2 assesses the presence and severity of ASD symptoms in individuals 2 years of age and older and can be completed in approximately 30–45 min. It contains three observational rating forms, which include the Standard Version Rating Booklet (CARS-2 ST), the High-Functioning Version Rating Booklet (CARS-2 HF), and the Questionnaire for Parents or Caregivers (CARS2-QPC). The CARS2-ST is most appropriate for children under 6 years of age with language and/or cognitive deficits. The CARS2-HF is designed primarily for verbally fluent children above 6 years of age with IQ scores at or above 80. CARS2-QPC is a caregiver questionnaire that can be used to obtain information about caregiver-reported behavior to complement clinician observations (Schopler et al., 2010).

The CARS-2 ST and CARS-2 HF yield scores that range between 15 and 60, with scores ranging between 15–29.5 and 15–27.5 indicating minimal-to-no symptoms, 30–36.5 and 28–33.5 indicating mild-to-moderate symptoms, and 37–60 and 34–60 indicating severe ASD symptoms respectively (Parkhurst & Kawa, 2017). Mayes et al. (2009) found that the CARS did not frequently misclassify children with ADHD, such that agreement between the CARS clinician ratings and the child's diagnosis was at 98% among children with ADHD diagnoses. Additional research evaluated ASD cutoff scores that could most accurately differentiate between ASD and ADHD. Prior research has shown that CARS scores typically decrease with increasing mental age and IQ. As such, a lower cutoff score (i.e., lower than a score of 30) on the CARS may most accurately identify children with ADHD. According to Mayes et al. (2012), a cutoff score of 25.5 on the CARS best differentiates between ASD and ADHD among children aged 1–16 with IQs of 80 or above, with only 3% of the ADHD sample scoring above the cutoff score.

Autism Diagnostic Interview—Revised (ADI-R; Rutter et al., 2003) The ADI-R is a structured interview that can be used to obtain a developmental history for children suspected of having ASD with a mental age of 2 years and above. The ADI-R typically requires 90–180 min to administer. The ADI-R can be used during a comprehensive diagnostic assessment in combination with the ADOS-2. The ADI-R is composed of 93 items that obtain information across four domains, including qualities of reciprocal interactions, communication and language, restricted, repetitive, stereotyped behaviors and interests, and age of onset of symptoms. The clinician codes each item response, and the corresponding scores are entered into the appropriate algorithm (i.e., diagnostic algorithm or current behavior algorithm). Scores must meet the cutoff criteria in each domain to indicate a diagnosis of ASD (i.e., social impairment = 10; communication and language = 8 (verbal) and 7 (nonverbal), restricted and repetitive interests or behaviors = 3, and age of onset = 1) (Rutter et al., 2003).

Like the ADOS-2, the psychometric properties of the ADI-R have been thoroughly investigated. Because ADHD could not be concurrently diagnosed with ASD prior to the DSM-5, the original validation samples did not include children with ADHD (Antshel & Russo, 2019). Research examining the specificity of the ADI-R among children referred for ASD diagnostic evaluations found that 30% of those with ADHD and 67% of those with ASD in the sample met algorithm criteria across all four domains. Further, none of the items on the ADI-R differentiated between children with ASD and children with ADHD. When both the ADI-R and ADOS-2 were used in conjunction, only 11% of children with ADHD met the criteria for ASD on both measures compared to 60–75% of children with ASD. As previously stated, prior studies investigating the specificity of the ADOS-2 indicated that it was better at distinguishing between these diagnostic groups. This suggests that there are differences in the social impairments in those with ASD and those with ADHD observed by clinicians during direct behavior observations, though they may be more difficult to discern with caregiver report measures (Grzadzinski et al., 2016).

Social Responsiveness Scale, Second Edition (SRS-2) The SRS-2 is a 65-item rating scale that assesses the presence and severity of social deficits in individuals aged 2 years, 6 months through adulthood, typically associated with ASD. Caregivers and teachers familiar with the individual's abilities across several social contexts should complete the rating scale. The SRS-2 takes approximately 15–30 min to complete; each item is rated on a 4-point Likert scale ranging from 0 (never true) to 3 (almost always true). The SRS-2 yields a total score, as well as scores across five subscales: social awareness, social cognition, social communication, social motivation, and restricted interests and repetitive behavior. Higher scores indicate increased social impairment on corresponding items.

Researchers have shown that the SRS has good predictive validity for ASD which is comparable to more lengthy diagnostic tools, like the ADI-R (Constantino et al., 2003). However, other researchers suggested that the SRS may be too general such that it may identify broad behavior problems, rather than those associated with ASD exclusively. In a study conducted by Hus et al. (2012), non-ASD behavior problems have been found to correlate with higher scores on the SRS in both children with and without ASD. Its lack of specificity when used among clinical samples is important to note as children with ASD often present with co-occurring conditions and children with behavior problems may have undetected social communication difficulties. Moreover, some research has suggested that the SRS may overidentify children with ASD, as it measures social impairments beyond those observed in ASD (Factor et al., 2017).

Due to the symptom overlap between ASD and ADHD, studies have examined the performance of the SRS-2 in distinguishing between the groups. One such study completed by Factor et al. (2017) found no significant difference in the total SRS-2 scores between the ASD + ADHD (i.e., with clinical symptoms of ADHD) and ASD − ADHD (i.e., without clinical symptoms of ADHD) groups; however, comorbid clinical ADHD symptoms were associated with increased difficulties in the social awareness and social competence domains of the SRS-2. Another study that evaluated the discriminant validity of the SRS-2 in clinical samples of children indicated that ADHD symptoms were associated with the total score on the SRS-2 when controlling for ASD. Only 16 items on the SRS-2 differentiated between ASD and other clinical diagnoses (Moul et al., 2015). As a result, it is recommended that multiple caregiver questionnaires be utilized to accurately differentially diagnose ASD and comorbid conditions in clinical populations.

The Checklist for Autism Spectrum Disorder Symptoms (CASD; Mayes, 2012) The CASD is a screening and diagnostic measure that consists of a list of 30 ASD symptoms that are scored as either present (i.e., current or past symptoms) or absent. It can be administered by clinicians in 15 min as a semi-structured interview with caregivers or completed in 10–15 min by caregivers/teachers as a checklist to later be scored by clinicians. Fifteen or more endorsed items indicate that the child's score falls within the ASD range on the measure. The CASD is uniquely designed to assess ASD symptoms that occur along a single spectrum, consistent with the DSM-5, and distinguish ASD from other comorbid conditions among children aged 1–17 (Mayes, 2012; Atlas & Powell, 2017).

The test author completed several studies indicating that the CASD differentiated those with ASD from those with ADHD with 99.5% accuracy (Mayes et al., 2009). In a follow-up study, the CASD, CARS, and Gilliam Asperger's Disorder Scale (GADS) were reported to have good specificity, such that the CARS and CASD accurately discriminated between 100% of the children with ASD and children with ADHD (Mayes et al., 2012).

ADHD Rating Scale—5 for Children and Adolescents (ADHD-RS-5; Dupaul et al., 2016) The ADHD-RS-5 is an 18-item measure that assesses the frequency and severity of ADHD symptoms and impairment according to the DSM-5. The symptom scale includes two subscales that evaluate inattention and hyperactivity-impulsivity. The impairment scale comprises six items across both the inattention and hyperactivity-impulsivity subscales. The impairment items include family/teacher relations, peer relations, homework functioning, academic functioning, behavioral functioning, and self-esteem. The ratings for the symptom and impairment scale are scored along a four-point Likert scale (0 = no problem; 1 = minor problem; 2 = moderate problem; 3 = severe problem) (Dupaul et al., 2016; Alhossein et al., 2022). Caregiver-report and teacher-report rating scales are available to obtain information about home and school behaviors, respectively. Each rating scale takes approximately 5 min to complete and is available in both a child (i.e., 5–10 years of age) and adolescent version (i.e., 11–17 years of age) (Dupaul et al., 2016).

The ADHD-RS-IV was found to not adequately differentiate between children with ASD and ADHD diagnoses (Hattori et al., 2006; May et al., 2018). Yerys et al. (2017) examined the use of the ADHD rating scale fourth edition (ADHD-RS-IV) among children with ASD without an intellectual disability. While the ADHD-RS-IV and related DSM-based ADHD screeners are frequently used among children with ASD, it was not normed or validated for those with ASD. The above-mentioned researchers found that the ADHD-RS-IV failed to meet goodness-of-fit criteria for factorial validity among children with ASD. The scale does not effectively separate the hyperactivity/impulsivity and inattention constructs in those with ASD. Future researchers should seek to revise certain items found to have problematic wording when used among children with ASD and re-evaluate factorial validity. These include items describing the following behaviors: difficulty sustaining attention in tasks or play, doesn't listen when spoken to directly, easily distracted, and fidgets or squirms in seats. Clinicians should use caution when interpreting the results of the questionnaire and evaluating ADHD symptoms in children with ASD. Clinicians should conduct thorough interviews with caregivers, particularly about ADHD symptoms on the questionnaire that require high social demands of the child (e.g., "Does not listen when spoken to directly") (Yerys et al., 2017).

The Conners Third Edition (Conners-3) The Conners-3 is a rating scale designed to assess ADHD and the most common comorbid disorders among children and adolescents 6–18 years of age. It contains parent, teacher, and adolescent self-report in long and short versions. In general, the long form takes approximately 20 min to complete, while the short forms can be completed in 10 min. The Conners-3 provides large normative samples and t-scores based on age and gender. The Conners-3 contains several content, index, and symptom scales that can be used to assess ADHD and certain comorbid conditions. One study found that Conner's rating scale was unable to adequately differentiate between ADHD and ASD (Ehlers et al., 1999), though no recent studies have evaluated the validity of Conners-3 in those with ASD. In general, few studies have sought to evaluate whether ADHD-specific assessment tools can differentiate between ADHD and ASD (May et al., 2018).

The Vanderbilt ADHD Diagnostic Rating Scales (VADRS) The VADRS is a rating scale for children aged 6–12 designed to identify the severity of ADHD symptoms, as well as symptoms related to other disorders that frequently co-occur with ADHD (i.e., oppositional defiant disorder, conduct disorder, anxiety, depression). In addition to symptom assessment, the scale includes performance impairment scales to assess academic, behavioral, and interpersonal impairment. Each item is scored on a four-point Likert scale and requires approximately 10 min to complete; informants are instructed to rate each item according to whether it has occurred during the past 6 months while the child was not taking ADHD medication. Both caregiver and teacher-rated scales are available to screen for ADHD symptoms and impairment in the home and school environments (Epstein & Weiss, 2012). No research has been conducted on the ability of the VADRS to differentiate ASD from ADHD diagnoses.

The Behavior Assessment System for Children, Third Edition (BASC-3; Reynolds & Kamphaus, 2015) The BASC-3 is a behavioral assessment for individuals aged 2–21. The BASC-3 includes several forms, including: Parent Rating Scales (PRS), Teacher Rating Scales (TRS), the Self-Report of Personality (SRP) (ages 6–21 years), Student Observation System (SOS), the Structured Developmental History (SDH), and a Parenting Relationship Questionnaire (PRQ). The BASC-3 offers a comprehensive approach to identifying and monitoring behavioral and emotional challenges in children and young adults. It includes validity indicators, composite scales, and four indexes; the BASC-3 can be completed in approximately 10–20 min (Reynolds & Kamphaus, 2015).

Among those with comorbid ASD and ADHD, domains of externalizing behavior, such as attention problems and hyperactivity, were found to be elevated, while internalizing symptoms, such as atypicality and withdrawal, did not differ between those with ASD alone and those with both ASD and ADHD diagnoses (Yerys et al., 2009; May et al., 2018). A recent study evaluated whether caregiver and teacher rating scales on the BASC-3 could effectively differentiate between ADHD and ASD to aid in differential diagnosis. The ASD and ADHD groups showed significant differences in all the ASD-related scales and insignificant differences in the ADHD-related scales, specifically the Attention Problems and Hyperactivity scales. On the BASC-3 caregiver and teacher rating scales, Atypicality, Withdrawal, Developmental Social Disorders, and Autism Probability Index scores were sensitive and differentiated ADHD and ASD with high accuracy (Zhou et al., 2020).

The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) The CBCL is a component of the Achenbach System of Empirically Based Assessment (ASEBA) that is used to identify behavioral and emotional difficulties in children and adolescents. The CBCL consists of two sets of forms, one for children aged 1.5–5 years old and one for children aged 6–18 years old to be completed by caregivers. A

CBCBL teacher report form (TRF) can be completed for children aged 6–18, and a youth self-report (YSR) is available for children aged 11–18. The CBCL is scored on a 3-point Likert scale (0 = not true; 1 = somewhat or sometimes true; 2 = very true or often true) and takes approximately 10–15 min to complete. The school-age assessment forms (CBCL/6–18), TRF, and YSR consists of questions on eight different syndrome scales: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior. They also contain six DSM-oriented scales which correspond with DSM diagnostic categories: affective problems, anxiety problems, somatic problems, ADHD, oppositional defiant problems, and conduct problems (Achenbach & Rescorla, 2001; Coulacoglou & Saklofske, 2017).

The CBCL was designed to screen for a variety of disorders contained in the DSM-5, but ASD and related conditions are not included on CBCL forms for children over 6 years of age. Previous research has found patterns of elevation on the CBCL among children with ASD, such that their average total scores were more elevated than children without ASD, with their scores for Social Problems, Thought Problems, and Attention Problems approximately two to three standard deviations above controls (Bolte et al., 1999; Mazefsky et al., 2011). Another study found that the CBCL adequately distinguished children with ASD from those with another psychological disorder and those without, with the Thought Problems scale being the best at discriminating those with ASD from typically developing peers (Duarte et al., 2003). Additionally, individuals with comorbid ASD and ADHD were found to have a higher degree of psychopathology (i.e., internalizing and externalizing symptoms) compared to those with ASD alone; however, no research comparing the profiles of children with ASD and children with ADHD or the ability of the CBCL to differentiate between the two conditions have been completed (Holtmann et al., 2007; May et al., 2018).

15.2.4.3 Assessment Challenges and Differential Diagnosis

Prior research has identified an association between a delayed diagnosis of ASD among children with a co-occurring developmental, psychiatric, and/or neurological disorder. More specifically, children with a pre-existing ADHD diagnosis may receive an ASD diagnosis later than their peers, irrespective of ASD symptom severity (Levy et al., 2010; Miodovnik et al., 2015). Miodovnik et al. (2015) examined the relationship between age at ADHD diagnosis and age at ASD diagnosis. In the study, nearly 20% of the participants ($n = 1496$) were initially diagnosed with ADHD. On average, children diagnosed with ADHD prior to ASD were diagnosed with ASD about 3 years after children for whom ADHD was diagnosed at the same time as ASD or later. These children were also about 30 times more likely to receive their ASD diagnosis after the age of 6. In general, overlapping symptoms between ADHD and ASD may delay a diagnosis of ASD in children with a pre-existing ADHD diagnosis by making it difficult to identify the presence of a co-occurring condition (Kentrou et al., 2019).

There are several challenges associated with differentially diagnosing ADHD and ASD. ADHD and ASD are both diagnosed based on observable behavior, and as such, there are no medical tests, single diagnostic assessment tools, or defining features that set them apart. Clinicians must rely on informant reports and carefully observed behaviors to make the diagnoses. Clinicians should have a working knowledge of both disorders to accurately assess them and determine whether symptoms are clinically meaningful, producing impairment, and most likely the cause of impairment. In children with ASD, symptoms of inattention and hyperactivity should produce significant impairment beyond that caused by ASD alone. Additionally, the age at which each disorder can be diagnosed typically differs (May et al., 2018). Diagnostic tools used for ASD show adequate reliability in children as young as 2 years of age, with caregivers typically reporting concerns with their child's development between 14 and 19 months of age (Matheis et al., 2016; May et al., 2018). Caregivers may begin to have concerns about ADHD symptomology in their children as early as 3–4 years of age; however, it can be difficult to reliably distinguish ADHD behaviors from typical development during early childhood. As a result, it is recommended that children not be evaluated for ADHD until they are at least 4 years of age, though the DSM-5 specifies that symptom onset may occur at any time prior to the age of 12. Children who received an ASD diagnosis during early childhood (i.e., between 18 months and 4 years of age) would not have been formally evaluated for ADHD at that time, which may result in undiagnosed and untreated ADHD symptoms. Clinicians should closely monitor ADHD symptomology in children with ASD as the conditions frequently co-occur, and an additional assessment may be necessary for children whose ASD was diagnosed in early childhood (May et al., 2018).

To aid in differential diagnosis, clinicians should avoid using the same observed behavior to fulfill both sets of diagnostic criteria. Clinicians should also avoid diagnostic overshadowing or assuming that all symptoms are attributable to an existing condition when the symptoms may actually suggest that a comorbid condition is present. When evaluating ADHD concerns in children with ASD, the child's developmental level should be considered. ADHD symptomology should be inappropriate for the child's developmental level rather than their chronological age (Hatch et al., 2021).

15.2.5 Treatment Options

15.2.5.1 Pharmacological Interventions

Pharmacological treatments can be effective at reducing the core symptoms of ADHD, including inattention, hyperactivity, and impulsivity (Davis & Kollins, 2012). There is a large evidence base for the use of psychotropic medication to treat ADHD in school-aged children, but less so for use among pre-school-aged children. There are currently no medications approved by the U.S. Food and Drug Administration (FDA) to treat the core symptoms associated with ASD. Rather, only two psychotropic medications, Risperidone and Aripiprazole (Abilify), are approved for symptoms associated with ASD, like irritability and aggression (Leitner, 2014). While the use of psychotropic medication among children with ASD has significantly increased in recent years, there is limited research on the safety and effectiveness of these treatments. This increased usage is partly due to psychotropic medications being prescribed to individuals with ASD to treat comorbid symptoms of hyperactivity and other ADHD-related impairments (Davis & Kollins, 2012).

Stimulant medication is the most widely researched psychotropic medication used to treat ADHD, though research findings investigating the efficacy of these medications to treat comorbid ASD and ADHD are variable (Davis & Kollins, 2012). Santosh et al. (2006) completed a trial that directly evaluated the response to stimulants (i.e., Methylphenidate or Dextroamphetamine) among children with ADHD alone and children with comorbid ADHD and ASD. The researchers reported an improvement in ADHD symptoms among the groups, and no differences in treatment response or side effects were found between the groups.

Other research has suggested that treatment responses to stimulant medications may differ among those with comorbid ADHD and ASD and ADHD alone. The Research Units on Pediatric Pharmacology Autism Network conducted a randomized, placebo-controlled trial of Methylphenidate with children ($n = 72$) diagnosed with ASD aged 5–14. The findings suggested that the stimulant medication reduced ADHD symptoms in approximately half of the children, compared to about 70–80% of the children with ADHD alone (Arnold et al., 2012). Additionally, stimulant medications may cause increased negative side effects, such as irritability, stereotypy, and self-injury, among children with ADHD and ASD (Davis & Kollins, 2012; Hatch et al., 2021). Based on available research, it is recommended that stimulant medication be considered for individuals with ASD who continue to exhibit symptoms of ADHD following evidence-based behavioral treatments for ADHD (Hatch et al., 2021).

Non-stimulant medications, such as Atomoxetine, have also been evaluated for comorbid ADHD and ASD symptoms. Researchers have shown that Atomoxetine demonstrated better tolerability (i.e., the degree to which an individual can tolerate adverse drug effects) in children with ADHD and ASD than stimulant medication (Murray, 2010; Davis & Kollins, 2012). Another placebo-controlled study indicated that non-stimulant medication effectively reduced symptoms of hyperactivity and impulsivity among those with ASD, but not inattention; few adverse effects were observed compared to stimulant medication. Additionally, Atomoxetine effectiveness may differ depending level of impairment, cognitive functioning, and ASD symptom severity (Arnold et al., 2006; Davis & Kollins, 2012). Atomoxetine has been found to be more effective among children with ASD with higher cognitive functioning and lower ASD symptom severity (Posey et al., 2006; Davis & Kollins, 2012).

15.2.5.2 Behaviorally Based Interventions

Behaviorally based treatment is the primary intervention recommended for ASD and is frequently recommended for ADHD in combination with medication (Hatch et al., 2021). Researchers have indicated that comorbid ADHD and ASD are associated with greater impairments in daily functioning than either condition alone, so effective services are crucial (Davis & Kollins, 2012). Interventions should be evidence-based and consider each individual's unique needs and strengths. While there is a large body of research on interventions for ASD and ADHD alone, research for treating these comorbid conditions is significantly less substantial (Hatch et al., 2021). No interventions have been developed to target comorbid ADHD and ASD specifically, but there are similarities among the interventions used to treat these conditions. These treatments utilize operant conditioning procedures drawn from social learning theory (Leitner, 2014; Davis & Kollins, 2012).

Psychosocial interventions, including parent training, behavioral therapies, and social skills training, are generally recommended treatments for both ADHD and ASD diagnoses. Research supports the use of behavior training for parents and children with ADHD, as well as cognitive behavioral therapy for adults with ADHD diagnoses (Davis & Kollins, 2012). Children with ASD as well as ADHD often experience difficulties with social skills and as such, social skills training may help to further improve these skills. While social skills training appears to effectively reduce social impairments (i.e., social communication and social interaction difficulties) among children with ASD, literature supporting treatment effectiveness for children with ADHD is limited (Davis & Kollins, 2012; Hatch et al., 2021). Early intensive behavioral intervention is also frequently recommended for ASD to target social communication, language, and behavioral difficulties in young children (Davis & Kollins, 2012).

15.3 Conclusion

While ADHD and ASD could not be diagnosed together prior to the DSM-5, it is presently recognized that the two conditions frequently co-occur. Comorbid diagnoses of ADHD and ASD are associated with increased difficulties in daily functioning compared to the presence of either diagnosis alone. As such, clinicians should screen for symptoms of ADHD in those suspected of having ASD and conduct a thorough assessment to help guide intervention. When evaluating comorbid ASD and ADHD symptoms, clinicians should gather information from multiple sources and consider using ASD-specific measures, ADHD-specific measures, and broadband psychiatric rating scales to help differentiate between ADHD and ASD symptoms. No interventions have been designed to target comorbid ADHD and ASD, though a number of pharmacological and behaviorally based interventions can be used to treat these symptoms.

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Measuring Impulsivity and Its Underlying Features in ADHD

16

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16.1 Introduction

Impulsivity can be broadly defined as the degree to which one tends to act on the spur of the moment without considering consequences (Linhartová et al., 2021). Impulsivity is one of the symptom domains in ADHD, and it can include varying behaviors ranging from unwanted or premature movements and speech leading to accidents, injuries, social conflicts, and problems to inability to wait and postpone a reward, to emotional outbursts, up to risky behaviors such as aggression toward others or self (self-harming, suicidal behavior), substance abuse, binge shopping, binge eating, purging behavior, and risky sexual behavior (Patton & Stanford, 2011). Previous studies showed that impulsivity comprises several dimensions; there is no single global impulsivity factor (Cyders & Smith, 2007; Linhartová et al., 2021; MacKillop et al., 2016; Stahl et al., 2014). Based on clinical evidence and research studies, impulsivity is a heterogeneous concept that can be underlined by impairment in several distinct functions.

Self-reported measures of impulsivity (also called personality measures of impulsivity) and clinical ratings and interviews are based on ratings of various impulsive behaviors or tendencies to act impulsively in a patient's life. By contrast, behavioral tests of impulsivity focus on measuring an underlying functional impairment behind impulsive behavior. Behavioral models typically distinguish impulsivity based on impaired behavioral inhibition and increased preference for immediate reward, labeled as impulsive action and impulsive choice (Winstanley et al., 2006; see Linhartová et al., 2021 for other labels used in the literature for the same impulsivity types). Behavioral inhibition can be defined as the ability to stop or interrupt one's unwanted or premature actions. Behavioral inhibition is a basic neurobiological function, and its reduction can be considered a core vulnerability for impulsive behavior. The ability to inhibit behavior can be influenced by cognitive abilities such as attention or working memory. On the other hand, choice impulsivity follows from a reduced ability to wait and a strong preference for immediate rewards at the expense of disadvantageous consequences; it involves complicated cognitive processes such as planning and the evaluation of consequences. Moreover, impulsivity is often associated with strong emotions, and people with deficits in emotion regulation have a higher probability of acting

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impulsively. This may be (but is not necessarily) limited to emotional situations (so-called emotional impulsivity or urgency—the tendency to act impulsively under the influence of emotions; Cyders & Smith, 2007; Whiteside & Lynam, 2001). In our previous work, we showed that patients with ADHD, as compared with healthy people, have increased impulsivity in all domains (self-reported, impulsive action, impulsive choice, emotional impulsivity; Linhartová et al., 2020).

This chapter provides an overview of impulsivity measures, based on different methods and impulsivity subtypes, and their use in ADHD. For each measurement type, we describe the most commonly used methods for assessing the different dimensions of impulsivity. The chapter is divided based on measurement types on impulsivity questionnaires and rating scales, behavioral tests of impulsivity, and neurophysiological measures of impulsivity. In each method, we summarize the information on the test validity, its use in clinical or research practice, and test results in patients with ADHD.

16.2 Impulsivity Questionnaires and Rating Scales

Impulsivity questionnaires and rating scales can be divided into self-reported questionnaires (often called trait or personality measures of impulsivity) and rating scales of impulsive behaviors that can be rated either by patients or observers (family members, teachers) or by skilled clinicians.

16.2.1 Self-Reported Questionnaires of Impulsivity

Impulsivity is included in most of the complex personality models. Eysenck (Eysenck & Eysenck, 1977) supported the thesis that impulsivity in different modalities relates to all major personality dimensions of the PEN (psychoticism, extraversion, neuroticism) theory. Buss and Plomin (1975) included impulsivity in the main dimensions of their temperament theory of personality development, along with emotionality, activity, and sociability. Impulsivity is not necessarily viewed as a negative trait in personality models. Sensation seeking (Zuckerman, 1969, 1994) is a personality dimension concept describing the individual need for arousal and stimulation. Similarly, Dickman (1990) distinguished functional and dysfunctional impulsivity by pointing out that acting without thinking can also be described as spontaneity and need not always lead to negative consequences. The most influential models of impulsivity are currently the traditional Barratt Impulsiveness Scale (BIS) (Barratt, 1959) and the more modern UPPS-P model of impulsivity (Cyders & Smith, 2007; Whiteside & Lynam, 2001).

16.2.1.1 The Barratt Impulsiveness Scale

The BIS was first introduced in 1959. Its 11th version has been in use for over 25 years (Patton et al., 1995). The scale has 30 questions. According to the authors (Patton et al., 1995), the scale yields six first-order factors (attention, cognitive instability, motor impulsiveness, perseverance, self-control, cognitive complexity) and three second-order factors (attentional impulsiveness, motor impulsiveness, non-planning impulsiveness). Thus, the scale distinguishes several impulsivity subtypes based on impairment in cognitive function, motor inhibition, and planning and considering consequences. However, many studies have failed to replicate the six-factor or the three-factor structure (e.g., Reise et al., 2013; Steinberg et al., 2013; Vasconcelos et al., 2012). Regardless of the lack of a clear factor structure, the BIS remains widely used and has been found to differentiate ADHD patients from healthy people on a common impulsivity score but not from other clinical groups with high impulsivity (Chamberlain et al., 2017; Roberts et al., 2016).

16.2.1.2 The UPPS-P Model

The UPPS-P model is named after the impulsivity dimensions it covers: urgency, (lack of) perseverance, (lack of) premeditation, sensation seeking, and positive urgency (Cyders & Smith, 2007; Whiteside & Lynam, 2001). The UPPS-P model was developed as an attempt to unify all the previous personality models of impulsivity by including 20 different impulsivity scales into one-factor analysis (Whiteside & Lynam, 2001). The model yielded four impulsivity factors, including urgency, the tendency to act impulsively under the influence of strong negative emotions; a fifth factor was later added by Cyders and Smith (2007), who stated that people also have a tendency to act impulsively under the influence of strong positive emotions (positive urgency). Thus, the scale is unique in including subscales directly focusing on emotional impulsivity. The original questionnaire consists of 59 items; higher scores in all UPPS-P subscales except sensation seeking were found in subjects with ADHD compared to healthy people (e.g., Lopez et al., 2015; Pedersen et al., 2016). Some studies also found differences in UPPS-P subscales between ADHD patients and other clinical populations (e.g., Brunault et al., 2020; Linhartová et al., 2020). Shortened versions of the scale for adults (Cyders et al., 2014) and for children over the age of eight (Geurten et al., 2021; Zapolski et al., 2014) are available, but low external validity and reliability do not support clinical use (see Watts et al., 2020).

16.2.2 ADHD Rating Scales with Regard to Impulsivity

Rating scales of impulsivity can be questionnaires for rating behavior frequency by patients and by observers such as parents, coworkers, or educators, or clinical interviews rated by a skilled clinician. Most rating scales and clinical interviews are based on DSM-IV/V criteria and investigate the presence of hyperactivity/impulsivity and inattention symptoms. Impulsivity is typically measured together with hyperactivity as a part of hyperactivity/impulsivity symptoms in clinical interviews.

16.2.2.1 Patient/Observer Rating Scales

Attention Deficit Disorder Evaluation Scales (ADDES)

ADDES questionnaires, published by Hawthorne Educational Services, are a family of assessment scales designed to assess children and adults. The most recent edition, ADDES-5 (McCarney & House, 2019), is intended for use with children from 5 to 17 years. The 60-item school version should be completed by educators; the 46-item home version is to be completed by parents or guardians. The items in the current version are formulated in agreement with DSM-V practices: ADHD-related behaviors and problems are rated by frequency on a six-point scale from "not developmentally appropriate" or "not observed" to "one to several times per hour." Both the 60-item and 46-item versions of (A-)ADDES were standardized on geographically representative samples in the United States. The total score is composed of subscales of inattentive and hyperactive-impulsive behaviors; the impulsivity rating is thus included within a common hyperactivity/impulsivity domain, and population-based standards and percentile scores are available from the publisher.

Adult Attention-Deficit/Hyperactivity Disorder Self-Report Scale (ASRS)

The adult attention-deficit/hyperactivity disorder self-report scale (ASRS; Kessler et al., 2005) has become the most widely used ADHD rating scale in the literature (Stanton et al., 2018). The ASRS was developed by a World Health Organization (WHO) advisory committee composed of ADHD experts in collaboration with the WHO World Mental Health (WMH) Survey Initiative (ASRS-v1.1 version; Kessler et al., 2005). ASRS was originally developed for adults; however, it has been increasingly used in adolescent populations (Adler et al., 2019; Green et al., 2019; Sonnby et al., 2015). Ustun et al. (2017) suggested an update of the short version based on DSM-5 criteria. The new short version has been designated the ASRS-5. The full version includes 18 questions in reference to the past six months rated on a 5-point Likert scale. The short version includes six questions rated likewise. The authors stated that the six-question screener outperforms the full 18-question ASRS. The full version is still useful for two basic reasons—(a) the administration of the full ASRS can significantly improve the classification of true cases among people who are positive on the six-question screener and (b) the full ASRS might be useful in charting clinical improvement among cases in treatment (Kessler et al., 2005).

The clinical form of the ASRS-v1.1 (available in more than 20 languages at: https://www.hcp.med.harvard.edu/ncs/asrs.php) has two parts. Part A is the short six-question screener, and part B is the remaining 12 questions. In part A, some answers are scored as positive at level 2 (“sometimes”) and higher, namely questions 1-3; the rest are scored as positive on level 3 (“often”) and higher. If four or more questions are scored as positive in part A, then the patient has symptoms highly consistent with ADHD in adults. Part B provides additional cues: four questions are scored as positive on level 2 and higher and the rest on level 3 and higher. Another format distinguishes the two factors embedded in the scale—inattention questions (Part A, questions 1-4 and 7-12) and hyperactivity/impulsivity questions (Part B, questions 5, 6, and 13–18). Thus, impulsivity is included in a common cluster with hyperactivity.

Barkley Adult ADHD Rating Scale (BAARS-IV)
The development of the Barkley Adult ADHD Rating Scale (BAARS-IV) was based on many years of experience diagnosing ADHD in children and adults (Barkley, 2011). The scale was originally based on DSM-III-TR criteria and later adapted to DSM-IV criteria for ADHD. The self-report version includes a section on current symptoms with 30 items, 27 of which are rated on a 4-point Likert scale. The remaining three questions ask about severity, age at symptom onset, and impairment. The first part of the scale (inattention) asks nine questions, the second part (hyperactivity) has five questions, and the third part (impulsivity) has four questions. Thus, impulsivity is measured as a single subscale. The next part is a unique feature of the BAARS—nine questions covering sluggish cognitive tempo, an original contribution of the author. Another section serves as a self-report of childhood symptoms (defined as symptoms occurring between 5 and 12 years of age; Barkley, 2011). The BAARS-IV is intended for adults 18–89 years old and has population norms for three age groups: 18-39, 40-59, and 60–89.

Brown Attention-Deficit Disorder Scales (BADDS), Brown Executive Function/Attention Rating Scales
The Brown Attention-Deficit Disorder Scales (Brown, 1996) focus on young adults and adolescents experiencing difficulties with student coursework. In 2001, it was revised to assess children as well (Silverman, 2012). The BADDS had 40 self-report items clustered around domains of ADHD in Brown’s executive dysfunction model: (a) ability to sustain attention and concentration, (b) ability to sustain energy and effort, (c) organization and activation for work, (d) managing affective interference, and (e) using working memory and accessing recall (Brown, 1996). The respondents indicate how much the listed feelings or behaviors have been a problem in the last six months on a 4-point scale; versions for older children and adults can also be administered in pencil-and-paper form, but the author prefers an interview (Brown et al., 2017). Excellent stability ($r = 0.87$) and internal consistency ($\alpha = 0.96$) of the overall scores have been reported (Serine et al., 2020). In 2018, the scales underwent a revision to better assess the complex impairment that impacts academic, social, emotional, and behavioral development for children from 3 years old and adults; the scales are now known as the Brown Executive Function/Attention Rating Scales. In Brown’s scales, impulsivity is included as part of cluster (a): the ability to sustain attention and concentration.

Conners’ Rating Scales and Conners’ Adult ADHD Rating Scales (CAARS)
Conners’ Rating Scales have been a traditional tool for assessing behavioral problems in children since the 1960s. Considerable confusion has arisen in the literature regarding the distinction between specific versions of these otherwise psychometrically well-constructed instruments (Gianarris et al., 2001). The CPRS-93 (Connors’ Parent Rating Scale), administered to parents, was introduced primarily as an instrument to identify

"hyperkinetic" children and to evaluate the effectiveness of drug treatment in controlling their behavior (Conners, 1973). Later, a version for teachers (CTRS, Connors' Teacher Rating Scale, 28 items) and an abbreviated version for parents, CPRS-48, were created (Goyette et al., 1978).

In both versions for parents and teachers, impulsivity-hyperactivity and inattention-passivity subscales were included. In the revised versions, the hyperactivity-impulsivity subscale is retained, and inattention and distractibility have become part of the broader cognitive problems subscale. The scales for teachers and parents are applicable from 6 to 18 years of age; the self-assessment scales are for children and adolescents from 8 to 18 years of age. The latest changes were aimed at achieving compliance with the DSM-V.

The Connors' Adult ADHD Rating Scale (CAARS) was published in 1999 (Conners, 1999). The CAARS contains two types of forms: self-report (CAARS-S) and observer ratings (CAARS-O). Within each of the two types, there are three versions: long, short, and screening. The long versions (CAARS-S:L and CAARS-O:L) have 66 items; the short versions (CAARS-S:S and CAARS-O:S) have 26 items and are used when administration time is limited or where multiple administrations over time are needed (e.g., treatment monitoring). Finally, the screening versions (CAARS-S:SV and CAARS-O:SV) contain a subset of 30 items that best distinguish individuals with ADHD from non-clinical individuals (Conners, 1999; Silverman, 2012). The CAARS is based on the DSM-IV symptom criteria for ADHD, the Conners' Rating Scales—Revised for Children and Adolescents, and the current conceptualizations of adult ADHD, and it thus includes impulsivity in common dimensions with hyperactivity.

Wender Utah Rating Scale (WURS)

The Wender Utah Rating Scale (WURS) was introduced in 1993 (Ward et al., 1993). It allows subjects to retrospectively recall the frequency and severity of ADHD symptoms and related problems experienced in childhood on a 5-point Likert scale. The WURS has 61 items. A 25-item version, WURS-25, was introduced at the same time (Ward et al., 1993). The WURS is based on the Utah ADHD criteria, and thus, it differs from the specific DSM criteria for ADHD.

A recent study in a clinical population (Gift et al., 2021) showed that the WURS has a five-factor structure: disruptive mood and behavior, ADHD, anxiety/dysphoria, social, and academic factors. These five factors have been found in normal college students (Calamia et al., 2018) and in parents of children with ADHD (Stein et al., 1995). Hanley et al. (2022) published another analysis with five different factors, including impulsivity/distractibility factor (impulsivity/distractibility, oppositional/conduct symptoms, academic performance, psychosomatic symptoms, and sociability/popularity).

16.2.2.2 Clinical Interviews

Diagnostic Interview for Adult ADHD (DIVA-5) and Young DIVA-5

The Diagnostic Interview for Adult ADHD (DIVA) is a semi-structured interview based on DSM-V criteria for ADHD administered by a skilled clinician (Kooij & Francken, 2010). The latest version DIVA-5 (Kooij et al., 2019) has three parts related to childhood and adulthood: inattention criteria (A1), hyperactivity and impulsivity criteria (A2), and age at onset and areas of impairment due to ADHD. The interview is given simultaneously to the patient and a partner or family member and takes about 90 minutes.

Impulsivity is evaluated by asking about behavior examples in the part "symptoms of hyperactivity-impulsivity." Questions focus on the frequency of fidgeting with hands or feet or squirming in seat, leaving seat in classroom or in other situations in which remaining seated is expected, running about or climbing in situations in which it is inappropriate, difficulty playing or engaging in leisure activities quietly, going or acting as if "driven by a motor," talking excessively, blurting out answers before questions have been completed, difficulty awaiting turn, interrupting or intruding on others.

DIVA-5 observer agreement was explored by Zamani et al. (2021). For hyperactivity/impulsivity in adulthood, Fleiss' kappa ranged from 0.71 to 0.93, and in childhood ranged from 0.76 to 0.93. To assess ADHD in children ages 5 to 17, the Young DIVA-5 was established (DIVA Foundation, 2017). The clinician should interview the young client and a parent or family member if possible. The interview takes around one hour. As far as we know, no studies exploring the psychometrics of the Young Diva-5 exist. The DIVA-5, Young DIVA-5, and their versions translated into different languages are available at: www.divacenter.eu for a small fee (10 euros). According to the authors, both methods can be used for both clinical and research purposes.

Conners' Adult ADHD Diagnostic Interview for the DSM-IV (CAADID)

Another frequently used clinical interview is Conners' Adult ADHD Diagnostic Interview for the DSM-IV (CAADID; Epstein et al., 2000). CAADID is a semi-structured interview used to assess the presence of ADHD symptoms in adulthood and childhood. The method is suitable for interviewing clients 18 and older. The first part can be administered as a clinical interview or completed by the patient as a self-report questionnaire. This part focuses on the demographic history, the developmental course of attention problems, ADHD risk factors, and comorbid psychopathology. The second part is administered by a clinician. It assesses the first four DSM-IV criteria, such as the presence of DSM-IV ADHD symptoms (Criterion A), age at ADHD symptom onset (Criterion B), the pervasiveness of the symptoms (Criterion C), and impairment caused by the symptoms during childhood and adulthood (Criterion D; Epstein & Kollins, 2006). As in DIVA-5, impulsivity cannot be assessed separately. Questions on hyperactivity/impulsivity symptoms include fidgets, difficulty remaining seated, restlessness/running about, difficulty being quiet, "on the go," talking excessively, blurting out answers, difficulty awaiting turns, and interrupting.

Epstein and Kollins (2006) examined the test-retest reliability and concurrent validity of the CAADID. Agreement between clinicians for hyperactive/impulsive symptoms in adult diagnosis was moderate (kappa = 0.60); childhood diagnosis was strong (kappa = 0.81). The concurrent validity of current symptomatology was explored by correlations with self-report questionnaires and observer-reported methods. Hyperactive/impulsive symptom correlations with self-report questionnaires were significant and reached a moderate value ($r = 0.50$). Correlation with the observer-reported method for hyperactivity/impulsivity was also significant and moderate ($r = 0.50$). The concurrent validity of past symptomatology was analyzed by correlations with self-reported retrospective methods and parent-reported retrospective methods. Significant correlations of hyperactive symptoms were $r = 0.48$ in self-reported retrospective methods. However, correlations between CAADID and the parent-reported retrospective method were not significant.

16.2.3 Conclusion: Impulsivity Questionnaires and Rating Scales

The most commonly used self-reported questionnaires for assessing impulsivity are the BIS and the UPPS-P impulsive behavior scale. Caution should be used when using the BIS due to its questionable internal validity. The UPPS-P scale enables measuring emotional impulsivity. Both scales have been found to distinguish between ADHD patients and healthy people; more data on the ability to distinguish patients with ADHD from other clinical groups is needed. Due to a lack of population norms, the scales are mostly useful in research practice and can be used to evaluate changes in impulsivity even after long-term interventions. In most ADHD rating scales and clinical interviews, direct scores for impulsivity cannot be computed. Typically, impulsivity is rated in a common cluster of hyperactivity/impulsivity based on DSM criteria. Thus,

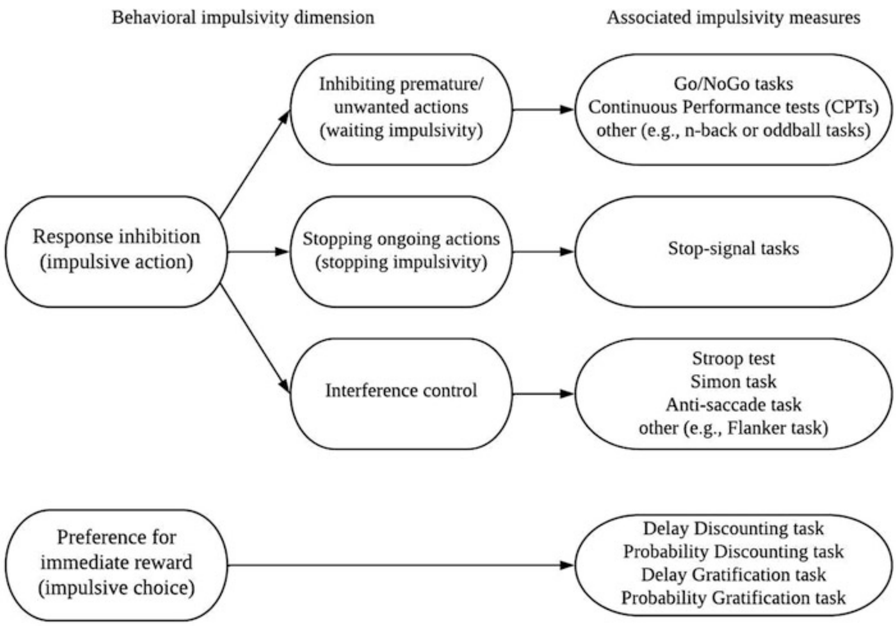

Fig. 1 Behavioral impulsivity dimensions and associated measures

ADHD rating scales and clinical interviews are generally not suitable for measuring impulsivity specifically.

16.3 Behavioral Tests of Impulsivity

Behavioral tests of impulsivity (see Fig. 1) can be distinguished into measures of response inhibition and further divided into tests of inhibiting premature or unwanted reactions (also called waiting impulsivity, Robinson et al., 2009), tests of stopping an ongoing action (also called stopping impulsivity, Robinson et al., 2009), and tests of interference control. These are typically rapid response tests, i.e., tasks presenting a long sequence of stimuli in a rapid tempo, and the subjects are instructed to react differently to specific stimuli. Impulsive choice, i.e., the preference for immediate reward (or the ability to postpone an immediate reward), is typically measured by delay or probability discounting tasks.

16.3.1 Response Inhibition Tests

Response inhibition is based on three different processes: inhibition of prepotent actions, inhibition of ongoing actions, and interference control (Barkley, 1997). Moreover, other cognitive processes are crucial for response inhibition, such as sustained attention, the ability to differentiate between targets, and working memory. Response inhibition tests typically include measures of attention. Which processes actually underlie impulsivity in ADHD has been discussed (i.e., response inhibition, sustained attention, or something else; Lijffijt et al., 2005).

16.3.1.1 Inhibition of Prepotent Actions: Go/NoGo and Continuous Performance Tests

The most frequently used behavioral tests measuring response inhibition of prepotent actions are the family of tests called Go/NoGo tasks or Continuous Performance tests. The tasks present respondents with a long sequence of rapidly alternating stimuli on a computer screen. There are two types of stimuli—Go (target) stimuli, to which the subject is instructed to react as quickly as possible (e.g., by pressing a keyboard button), and NoGo (non-target) stimuli, to which the subject is instructed not to react (i.e., to inhibit response). The tasks can be further divided into two categories based on the ratio of Go to NoGo stimuli. Tasks with a prevalence of Go stimuli are considered predominantly tests of response inhibition since the majority of Go stimuli establish a prepotent action in each trial (i.e., the dominant response is active, and response inhibition is loaded; Huang-Pollock et al., 2012; Wessel, 2018). Typically, tasks with prevalent Go stimuli are referred to as Go/NoGo tasks (GNG). Tasks with the prevalence of NoGo stimuli are considered predominantly tests of sustained attention (the ability to maintain attention over an extended period) since the dominant response in the task is passive, and the subject needs to sustain attention to monitor the occurrence of the target stimuli (Huang-Pollock et al., 2012). These tasks are traditionally referred to as Continuous Performance Tests (CPT; Rosvold et al., 1956). However, multiple variants of CPT have been developed, and some CPT tests currently involve a prevalence of Go stimuli. This applies, for example, to the widely used Conners' CPT (Conners et al., 2003) and also tasks labeled as "sustained attention to response" tasks—SART (Robertson et al., 1997). In addition to the well-known Conners' CPT, other commercially used variants of CPTs are available (Hall et al., 2016).

The main outcomes of GNG and CPT tests are: (1) Go omissions (i.e., the percentage of missed reactions to Go stimuli), which are considered mainly a measurement of sustained attention; (2) percentage of NoGo commissions (i.e., percentage of erroneous reactions to NoGo stimuli), which are considered mainly a measurement of response inhibition; and (3) Go reaction times (i.e., mean or variability of reaction time to Go stimuli). Additional outcome variables can include NoGo commission reaction time or overall reaction accuracy. The tasks with a higher percentage of Go stimuli and faster trial presentation produce more NoGo commissions and higher reaction time variability; the tasks with a higher percentage of NoGo stimuli produce more Go omissions (Ballard, 2001; Huang-Pollock et al., 2012; Nieuwenhuis et al., 2003; Wessel, 2018). The distinction between response inhibition and sustained attention has also been supported by different neural patterns for each function (Hwang et al., 2019).

Except for the Go:NoGo stimuli ratio, the GNG and CPT tasks can substantially differ in a myriad of other parameters, such as the type of stimuli (e.g., visual or auditory), the complexity of stimuli (e.g., symbols vs. letters vs. pictures), stimuli and inter-stimulus-interval (ISI) durations and their variability, the overall length of the task, the number of stimuli, and other features that might significantly impact the task cognitive load and, subsequently, participant task performance (e.g., Huang-Pollock et al., 2017; Schmidt et al., 2019; Simões et al., 2021). The task is more cognitively challenging when (1) there is a higher prevalence of either stimulus type, (2) the stimuli durations are faster and more varied, (3) it is more difficult to distinguish Go stimuli from NoGo stimuli, and (4) the Go trial is defined not as a single symbol, but as a specific sequence of symbols (e.g., the AX-CPT (MacDonald, 2008); or n-back tasks (Frost et al., 2021; Kirchner, 1958).

Results in ADHD

According to meta-analyses, both children and adults with ADHD make more Go omissions and more NoGo commissions, and they have higher reaction time variability than healthy individuals in GNG and CPT tasks with moderate effect sizes (Huang-Pollock et al., 2012: 47 studies in children with ADHD; Mowinckel et al., 2015: 47 studies in adults with ADHD). Huang-Pollock et al. (2012) concluded that the Go omissions increase over time in children with ADHD as compared to healthy children (i.e., attention declines with time more strongly in children with ADHD) and that this is primarily driven by the increased difficulty children with ADHD have detecting targets from non-targets. Thus, it can be expected that the differences between children with ADHD and healthy children will be more pronounced in tasks where Go and NoGo stimuli are similar (Huang-Pollock et al., 2012). Although sustained attention is defined as a process in time, and there are data suggesting that the difference between children with ADHD and healthy children might be in the course of the performance during the task, most studies do not provide time course data (Huang-Pollock et al., 2012).

Use Recommendations

Results of GNG and CPT in ADHD may depend on task characteristics such as inter-stimulus intervals (Huang-Pollock et al., 2017) and task difficulty levels (Ging-Jehli et al., 2021). The results are also strongly influenced by participant characteristics such as age (e.g., Mani et al., 2005), gender (e.g., Hasson & Fine, 2012), medication (e.g., Cedergren et al., 2022), and socioeconomic status (e.g., Ballard, 2001; Hasson & Fine, 2012). Because of the large variability in task parameters and the dependence of task results on task and participant parameters, diagnostic use of GNG and CPT tasks has been repeatedly not recommended (Riccio & Reynolds, 2001; Spencer, 2018). The results show low clinical validity, have little correlation with patient or parent ratings, and have poor sensitivity in identifying people with ADHD (Adamou et al., 2022; Baggio et al., 2020; Brunkhorst-Kanaan et al., 2020; Scimeca et al., 2021). On the other hand, an easy modification of task parameters can be used to test specific hypotheses in research. Moreover, CPTs have a history of use as an indicator of medication effects since the task performance reacts quickly to stimulant intake (Cedergren et al., 2022; Losier et al., 1996). GNG and CPT tasks can also use emotional or disorder-specific stimuli that can lead to more ecologically valid experiments (e.g., Czapla et al., 2015). In children with ADHD, CPT in a virtual classroom environment is tested as a more ecologically valid variant of the task (Parsons et al., 2019). Researchers using GNG and CPT in ADHD tests are strongly recommended to report all task parameters, report performance over time, and control for medication and sleep.

16.3.1.2 Inhibition of Ongoing Actions: Stop-Signal Task

The stop-signal task (SST) is a variant of the Go/NoGo task in which every trial begins with the presentation of a Go stimulus that is in some percentage of trials (stop trials) followed by a stop signal. The task was designed to measure the ability to stop one's ongoing actions (Logan & Cowan, 1984). The participant is instructed to react as quickly as possible to the Go stimuli and, at the same time, to inhibit their response when the Stop signal is presented. The procedure is based on a "horse race" model stating that response inhibition is produced through a race between the Go process (triggered by Go stimulus presentation) and the Stop process (triggered by stop-signal presentation; Verbruggen & Logan, 2009). The main outcome variable is the stop-signal reaction time (SSRT), which estimates the individual time needed to stop one's ongoing actions (and which cannot be measured directly). There are several methods of SSRT estimation using Go reaction time and Stop signal delay (SSD), which is the period between the Go stimuli onset and the Stop signal onset in Stop trials (Verbruggen et al., 2019). SSD can either be fixed or adjusted during the task (i.e., the tracking procedure; Verbruggen & Logan, 2009). If the subject correctly inhibited their response in the last Stop trial, the SSD increases and makes the inhibition in the next trial more difficult. If the subject incorrectly reacted during the last Stop trial, the SSD decreases and makes the inhibition in the next trial easier. The tracking procedure should lead to an approximate probability of 0.5 of reaction when the Stop signal is presented and makes the estimation of SSRT easier. It is recommended to use two types of Go stimuli (e.g., left and right arrows or two different letters), salient Stop signals (either auditory or visual), tracking procedures, and a minority of Stop trials (Verbruggen et al., 2019). In ADHD, SSTs typically use tracking procedures, auditory stop signals, and a minority of stop trials, and the task is administered to children from about 6 years old up to adults (Lijffijt et al., 2005).

Results in ADHD

According to a meta-analysis of 29 studies, children and adults with ADHD exhibit slower SSRT and more variable reaction times (Lijffijt et al., 2005). Children with ADHD also showed slower reaction times; there was a significant difference between mean RT and SSRT only in adults. Lijffijt et al. (2005) suggest a more general attention deficit in children with ADHD characterized by frequent lapses in attention, while there is a more specific inhibition deficit in adults characterized by the difference between reaction time and SSRT. Tillman et al. (2008) compared performance on the Stop Signal task in 525 children between 4 and 12 years. Younger children had slower SSRT, lower probability of inhibition, slower and more variable reaction times, boys had a lower probability of inhibition than girls, and SSRT was linked with inattention symptoms rather than hyperactivity/impulsivity symptoms. The study suggests that the stopping ability grows dramatically around age 6. Similarly, Lee, Wu, Tsai, and Yang (2016) found that preschool children with ADHD made more omission errors than healthy preschool children, but they were comparable in SSRT, suggesting the stopping inhibition might not yet be mature at this age.

Use Recommendations

Researchers using SST in ADHD are encouraged to follow the Consensus Guide from 2019 (Verbruggen et al., 2019). SST is probably not suitable for children under age 6. As in GNG and CPT tests, SST can be influenced by a number of task parameters that should therefore be fully reported.

16.3.1.3 Interference Control Tasks

Interference control refers to the ability to ignore or inhibit internal or external competing information (i.e., distractors) to focus attention on goal-relevant information (Nigg, 2017). Thus, low interference control can produce impulsive behavior through the inability to focus attention in the desired direction and through distractibility by irrelevant cues and distractors. The most frequently used tasks for interference control measurement are described in this part.

Stroop Test

The standard Stroop test (Stroop, 1935) consists of three parts. At first, participants read 100 words written in a black font (word card = W), and their word reading speed is measured. Then they name the colors of 100 rectangles or the word "XXXX" (color card = C), which assesses color naming speed. Lastly, they name the color of 100 incongruent color words (color-word card = CW) as fast as possible. This interference card requires participants to name the font color (blue, green, yellow, red) while ignoring the semantic meaning. Apart from the classic Stroop test, versions such as the Golden Stroop test (Golden, 1978) and the computerized Stroop test were developed. The Golden Stroop test has the same structure as the standard version, but participants have a limited time in which to name as many items as possible for each card, and their correct responses are counted. In the computerized Stroop test, congruent color words, neutral non-color words, and incongruent color words are presented either at once or one at a time. The respondents answer orally or by pressing the buttons with the correct answer, and their reaction time is recorded.

The Stroop interference is usually quantified as the difference score or Golden's interference score (Lansbergen et al., 2007). The difference score is calculated as the difference between the color (C) and color-word (CW) scores. A higher difference score indicates more difficulties with suppressing semantic meaning and, therefore, higher interference. Golden's (1978) interference score assumes the time for naming a color-word item equals the time needed for suppressing the reading of a word plus the time to identify a color. Although the Golden scoring method is frequently used in international studies (Scarpina & Tagini, 2017), Lansbergen et al. (2007) highlighted that it is not adequately corrected for inter-individual differences in reading skills.

Results in ADHD

Lansbergen et al. (2007) pointed out that previous meta-analyses excluded the computerized version of the Stroop test (Hervey et al., 2004; Homack & Riccio, 2004; van Mourik et al., 2005), focused only on children (Homack & Riccio, 2004; van Mourik et al., 2005) or adults (Hervey et al., 2004) with ADHD, and did not report which Stroop test variant the authors used (Frazier et al., 2004). More importantly, meta-analyses included studies that used different and inaccurate computing methods for Stroop interference. Therefore, Lansbergen et al. (2007) reviewed 48 studies comparing the Stroop effect between patients with ADHD or hyperactivity and healthy controls. The study covered all age groups and all Stroop test variants. Studies using the Golden quantification method were excluded. Mean effect sizes of difference scores for interference in ADHD were 0.24 across all studies. However, using time per card or item as an outcome variable had an effect size of 1.11. Consistency analyses suggested higher interference levels in respondents with ADHD than in the healthy controls. Overall, meta-analyses on using the Stroop test for inhibitory control in ADHD yielded significant but small to moderate effects (Lansbergen et al., 2007; van Mourik et al., 2005).

Simon Task

The main idea of the Simon task (Simon, 1990) is that reactions are faster and more accurate when the required response corresponds with the location of the stimulus. In this task, participants sit before a computer and see a single stimulus on the left or the right side of the monitor. They must indicate the item's identity by pressing the left or right button (Mullane et al., 2009). For example, respondents are told to press the key according to the arrow's direction when using the left and right-pointing arrows as stimuli. In the congruent condition, a right-pointing arrow is presented in the right half of the screen, whereas the left-pointing arrow is in the left half of the screen. In the incongruent condition, the arrows are in the opposite monitor side than the way they are pointing. Since there is evidence of the Simon effect in multiple sensory modalities, visual, auditory, and tactile stimuli may be used (Welch & Seitz, 2013).

The level of interference is quantified as a difference score (also called the congruency effect). The mean reaction time or a per cent of correct answers in congruent trials is subtracted from the mean reaction time or per cent of correct answers in incongruent trials. Higher scores indicate poorer interference control. Due to the subtraction, the difference score is controlled for individual differences in speed and response when using reaction time as a dependent variable (Mullane et al., 2009).

Results in ADHD

Mullane et al. (2009) conducted a meta-analysis of 12 studies exploring performance in children with ADHD and healthy controls in the Simon task and the similar Flanker task. Results indicated significant group differences in which children with ADHD were more susceptible to interference. However, the authors did not distinguish between studies using the Simon task and the Flanker task. Several studies supported a significant interference effect in the Simon task in adults with ADHD (Sebastian et al., 2012; Suarez et al., 2015).

Anti-Saccade Task

The anti-saccade task is an oculomotor task focusing on inhibitory control during the presentation of visual distractors (Maron et al., 2021). A central fixation point, usually a white cross, is presented to the participant. In a short period of time, this fixation marker is turned off while simultaneously displaying a peripheral target. Participants are given instructions to look in the direct opposite location of the peripheral target, therefore activating inhibitory control processes to suppress reflexive eye movements. Eye movements are recorded during the task; the main outcomes of the task include latency (eye movement reaction time taken as the difference between target appearance and initiation of the eye movement), directional errors (eye movements made to the wrong location), or anticipatory saccades (premature eye movements before the target appearance; Maron et al., 2021).

Results in ADHD

According to a meta-analysis of 26 anti-saccade task studies in ADHD (Maron et al., 2021), children with ADHD, compared to healthy controls, have longer response latencies with moderate effect sizes and produce more directional errors. Subsequent research mostly confirms such results. The most persistent and stable result in children with ADHD is an increase in directional errors (Bucci et al., 2017; Duval et al., 2018; Fernandez-Ruiz et al., 2020; Huang & Chan, 2020) showing a reduced ability to inhibit automatic responses when novel stimulus occurs. Regarding the reaction time needed for the correct spot location in ADHD as compared to healthy controls, studies had mixed results (higher time in ADHD: Duval et al., 2018; Fernandez-Ruiz et al., 2020; no difference: Bucci et al., 2017; higher time in healthy controls: Huang & Chan, 2020). Duval et al. (2018) also reported increased anticipatory saccades in children with ADHD. Studies can be influenced by subjects' medication, since methylphenidate, both after single-dosage and long-term usage, normalizes anti-saccade performance parameters such as latency and a number of direction errors (Bucci et al., 2017; Duval et al., 2018; Fernandez-Ruiz et al., 2020).

Use Recommendations

As in previous behavioral tests, the validity of interference control tasks is related to the participant and test characteristics. For example, the evaluation of interference could be affected by age, sex, education, and intelligence (Stoet, 2017; Van der Elst et al., 2006; Van der Lubbe & Verleger, 2002). The ability to read and name colors quickly is critical in the Stroop task since individuals who are poor in reading may have biased interference estimates (Lansbergen et al., 2007). Various versions of the Stroop test and different methods of computing the Stroop effect can initiate different interference levels (Lansbergen et al., 2007; Salo et al., 2001). In recent years, the computerized Stroop test has gained in popularity. According to dos Santos Assef et al. (2007), an advantage of the computerized version over the classic version is the precisely recorded reaction time, which increases the test sensitivity. Lansbergen et al. (2007) also supported the idea of using a computerized version because of better control over experimental situations leading to significance because of the relatively low variance of interference scores. It also prevents inaccurate scoring by observers. However, in the computerized version, each stimulus may be presented in isolation on the screen, eliminating interference from the distraction of presenting stimuli simultaneously (dos Santos Assef et al., 2007). Thus, when using a computerized version, it is better to establish experiments in a similar structure as the card original. The computerized method may be used in neuroimaging studies for studying neural correlates of attention and interference processes (Penner et al., 2012). Mullane et al. (2009) considered the Simon task a better choice than the Stroop test for measuring interference control in ADHD since the Simon task is not influenced by the ability to read or speak. The Simon task is also valid for measuring the activity of the anterior cingulate cortex, the brain area responsible for interference control and conflict monitoring (Fan et al., 2003). Medication should always be taken into account because of interference control test sensitivity to methylphenidate medication.

16.3.1.4 Does Inhibition Performance Reflect Inhibition Deficits in ADHD?

Some authors have argued that inhibition deficits in ADHD might not be caused by impaired inhibition per se but may instead be the result of other impairments related to attention or other cognitive functions. In a large meta-analysis of 319 studies involving various rapid response tests, Kofler et al. (2013) found that children and adults with ADHD generally have more variable response times but are not slower. The variability is strongly reduced by methylphenidate but unaffected by other medications or psychosocial interventions. However, the results were not specific for ADHD subtypes and were not specific compared to other clinical groups, so the large variability in response times seems to reflect general psychopathology.

Another concept that may underlie inhibition deficits in ADHD is post-error slowing, i.e., adaptive slowing of one's reaction following a mistake, giving a better chance for reparation. In their meta-analysis of 15 studies, Balogh and Czobor (2016) found that while healthy people slow their reactions after an error, especially in slow-speed situations (long ISI times), patients with ADHD sustain their responses or even increase their speed.

Other functions compromising inhibition in ADHD can be distractibility, or in other words, the interference control described above, or the ability to distinguish different visual symbols (Huang-Pollock et al., 2012). Some tasks can also be more prone to be influenced by working memory (e.g., complex GNG, CPT tasks, and n-back tasks) or reading and speaking abilities (Stroop task). In a recent study, Mann et al. (2021) also showed that inhibition performance in SST in children with ADHD was not associated with ADHD symptoms but with sleep problems. Further, some studies suggest that children with ADHD might perform better in inhibition tasks with high motivational aspects (Slusarek et al., 2001), like interesting game features or rewards.

16.3.2 Reward Processing: Delay and Probability Discounting

Delay discounting or temporal discounting tasks measure individual willingness to postpone a reward if they have to wait for it. The higher the delay discounting, the less people are willing to wait for delayed rewards and to postpone immediate rewards, even at the expense of future losses (Ainslie, 1975). High values of delay discounting implicate low tolerance for delay and high decision impulsivity (or impulsive choice; Winstanley et al., 2006). In other words, for people with high impulsive choices, the value of a reward drops rapidly if they have to wait for it. Increased (i.e., steeper) delay discounting is reliably found in people with substance addiction (Amlung et al., 2016), behavioral addiction (Weinsztok et al., 2021), and obesity (Amlung et al., 2016); it predicts outcomes of substance abuse treatments and intentions for treatment (Athamneh et al., 2017; MacKillop & Kahler, 2009; Stanger et al., 2012; Syan et al., 2021; Turner et al., 2021; Yoon et al., 2007).

In delay discounting tasks, the participants are asked to answer a set of questions requiring a choice between a smaller but immediate reward and a higher but delayed reward. Different immediate reward amounts are displayed for each combination of a delayed reward and a delay period until an “indifference point” is determined for the combination (Richards et al., 1999). The indifference point (IP) is the immediate reward amount with the same subjective value as the higher delayed reward. Across human and nonhuman species and regardless of reward type (Rung & Madden, 2018), the discounting function has a hyperbolic shape, i.e. the value of a reward gradually decreases with the time we have to wait for it (see Fig. 2 for illustration). There are two commonly used indices of discounting: the

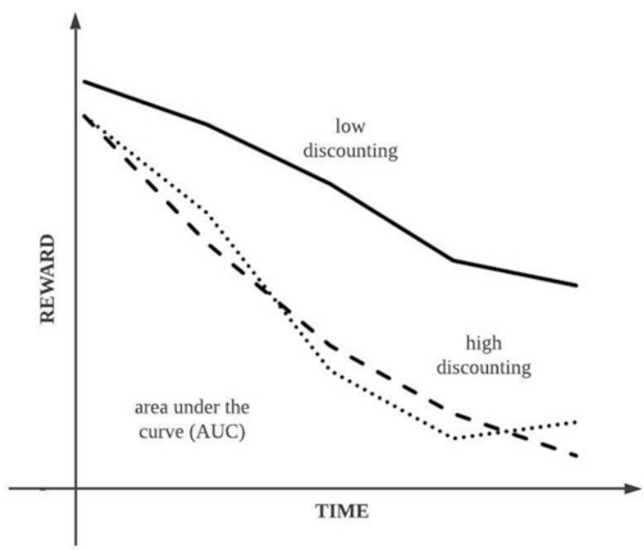

Fig. 2 Delay discounting function illustration. (Modified figure from Linhartová et al., 2020.)

discounting parameter k and the Area Under the Curve (AUC). The k parameter can be estimated from indifference points for a specific delayed reward and a set of different delays using a hyperbolic function across multiple delays (D) on the x-axis and a fixed delayed reward (DR) amount: DR = IP/(1 + k * D) (adjusting-amount procedure, Mazur, 1987). Higher values of k indicate steeper discounting with increased delay and higher levels of impulsive choice. The second index, AUC, is derived by connecting the indifference points for multiple delays and computing the area under the line (Myerson et al., 2001). The higher the AUC, the slower the discounting, and the lower the impulsive choice. The advantage of AUC is its independence from the theoretical discounting function used to derive k; the distribution of the k parameter is also typically strongly skewed (Linhartová et al., 2020). Probability discounting is another test measuring impulsive choice based on the same principle, but the probability of getting a reward is manipulated instead of a temporal delay (Richards et al., 1999; Shead & Hodgins, 2009).

As in response inhibition behavioral tasks, there is a large variability of parameters in delay discounting tasks. The tasks can include hypothetical or real incentives. The tasks with hypothetical incentives do not provide real rewards or waiting times. As a consequence, a large scale of rewards and delays from days to years can be applied (Odum, 2011). Discounting is typically less steep for high rewards, meaning that people would rather wait longer if the reward is high, and the reward value drops more rapidly in time if the value is low (Linhartová et al., 2020). In hypothetical tasks, it is easy to use other than monetary rewards, which tend to show results more closely associated with targeted problem behavior, e.g., cigarette discounting in smokers (e.g., Bickel et al., 1999), sexual discounting in risky sexual behavior (Johnson et al., 2021), food discounting in correlation with body fat (Rasmussen et al., 2010), or hand-washing discounting in OCD symptoms (Ong et al., 2019). Similarly, toys can be used as incentives in tasks designed for children (e.g., Utsumi et al., 2016).

Tasks using real incentives and/or real waiting times mean that the participant either gains a reward at the end of the task based on their choices, or they gain small rewards right after their choices and they experience real delays (typically in seconds) if they prefer delayed choices (Experiential Choice Task, Simple Choice Paradigm, Choice Delay Task, or Maudsley Index of Delay Aversion, see Marx et al., 2021 for overview). Besides small monetary rewards, other reward modalities can also be used in real incentive tasks such as small portions of food (e.g., Dong et al., 2016) or playtime in tasks for children (e.g., Rosch & Mostofsky, 2015). In general, studies suggest that money is discounted less steeply than other commodities (Odum, 2011) and that hypothetical and real rewards are strongly correlated and discounted at similar rates (Rasmussen et al., 2021; Seaman et al., 2022; Steele et al., 2019), but discounting gets steeper with real experiences of delays (as compared to hypothetical delays, Steele et al., 2019)

Since delay discounting tasks are often time-consuming, short variants of estimating the aversion to delay were developed. The Monetary Choice Questionnaire (MCQ; 27 items; (Kirby et al., 1999) and the Food Choice Questionnaire (FCQ; 27 items; (Hendrickson et al., 2015) are questionnaire variants of delay discounting tasks involving a fixed set of choices between smaller immediate and higher delayed rewards (money and food, respectively). Further, Koffarnus and Bickel (2014) developed a 5-trial adjusting delay task (ADT-5) that is an innovative method of rapid discounting rate assessment that can estimate the discounting rate in about a minute. According to its authors, it yields similar discounting rates as long adjusting procedures.

Results in ADHD

The latest meta-analysis of delay discounting tasks in ADHD included 37 studies mainly in children and adolescents with ADHD and also less frequent studies in adults with ADHD and compared adjusting delay discounting tasks and experiential (simple choice) discounting tasks

(Marx et al., 2021). The results showed that both paradigms yielded small to medium effect sizes for steeper discounting in ADHD participants than controls. With real incentives, ADHD participants were more prone than healthy controls to impulsive choices in experiential paradigms but not in adjusting delay discounting paradigms. As the authors pointed out, the role of the results for rewards in adjusting delay discounting paradigms might be biased by the fact that most of these studies use hypothetical rewards and almost exclusively hypothetical delays; in effect, the roles of hypothetical reward and hypothetical delay may be confounded. According to a review by de Castro Paiva et al. (2019), children with ADHD tend to have higher discounting, especially when using real rewards (money, food, toys) and real delays. The majority of reviews and meta-analyses shows that younger children with ADHD show steeper delay discounting than adolescents (de Castro Paiva et al., 2019; Patros et al., 2016; Pauli-Pott & Becker, 2015). Delay discounting also tends to get significantly steeper in highly cognitively demanding situations in children with ADHD than in healthy children, suggesting that choice impulsivity might be even more pronounced in children with ADHD under high cognitive load (Fabio et al., 2020; Martinelli et al., 2017). Further, the administration of stimulants led to decreases in delay discounting in children (9–12 years) with ADHD, but only in tasks with real rewards rather than hypothetical rewards (Shiels et al., 2010). The authors argued that tasks with real rewards and real delays might be more sensitive to state changes, while hypothetical tasks are more correlated with trait impulsivity indices, so the choice of the task might depend on the purpose of the study (Shiels et al., 2010). Studies of delay discounting in adults with ADHD are less frequent than in children, are typically characterized by small samples, and have so far produced mixed results (Dai et al., 2016; Linhartová et al., 2020; Mowinckel et al., 2015).

Use Recommendations

A delay discounting task is a useful measure of choice impulsivity that can be modified according to age or specific problems. While some tasks can be highly time-demanding, short questionnaire versions are available that seem to yield similar results. The results can be influenced according to hypothetical/real rewards and hypothetical/real waiting times chosen. Children with ADHD might be more sensitive to impulsive choice when using real incentives and waiting times or under high cognitive load. Since delay discounting tasks are sensitive to measuring impulsivity in substance abuse or food-intake problems, comorbidities should be monitored when using this task. The discounting parameter k may be influenced by the theoretical function used for its derivation and disadvantageous because of its typical steeply skewed distribution. It is recommended to report both k and AUC parameters.

16.3.3 Conclusion: Impulsivity Behavioral Measures

Behavioral measures of impulsivity are typically strongly influence by task and participant parameters; thus, clinical or diagnostical use of the tests is limited. On the other hand, behavioral tests are typically focused on a specific impulsivity dimension or function; thus, impulsivity profiles can be created by using multiple behavioral tests, which can bring more valuable information than a single measure, considering that impulsivity is a multidimensional construct. Previous studies have shown that behavioral dimensions of impulsivity are mostly independent and not associated with each other (Linhartová et al., 2021; MacKillop et al., 2016; Stahl et al., 2014) and that clinical populations can be distinguished based on impulsivity profiles drawn from multiple tests (e.g., ADHD patients from patients with borderline personality disorder, Linhartová et al., 2020). Patients with ADHD, as compared to healthy people, show deficits in all behavioral dimensions of impulsivity (Lansbergen et al., 2007; Lijffijt et al., 2005; Linhartová et al., 2020; Marx et al., 2021), pointing towards a complex self-control deficit in ADHD. The researcher should carefully monitor and report in detail on task and participant characteristics that can influence the test results when using any behavioral test of impulsivity.

16.4 Neurophysiological Measures

Neurophysiological measures of impulsivity are intended to find biologically based measures or markers of impulsivity. Describing the connection between physiological states or processes and impulsivity facets may contribute to improving the understanding of this transdiagnostic factor and may also help to develop new treatments and enhance current treatment options. As one of the long-term goals of neuropsychiatry is personalizing treatment and describing biological correlates of psychiatric disorders, the physiological approach is becoming more significant.

16.4.1 Autonomous Nervous System-Based Measures

The autonomous nervous system (ANS) consists of two main branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS, which prepares bodies and minds to face external or internal challenges and dangers, is usually associated with the "fight or flight" response. The PNS is responsible for homeostasis, occurs during rest, and begins the restoration phase after a stress response. Several ANS-based indicators have been studied in ADHD and other impulsivity-related disorders. **Heart rate (HR)** or resting heart rate is a physiological measure reflecting the relative activation of PNS and SNS (Deutz et al., 2019) with more impulsive individuals, both adults and children, having lower heart rates (Herman et al., 2018). **Respiratory sinus arrhythmia (RSA)** is heart rate variability in synchrony with respiration, represented mainly by the R-R interval, and is considered a PNS activity indicator with positive/higher values showing PNS excitation and possible deficits in self-control (Yasuma & Hayano, 2004; Zeytinoglu et al., 2020). The term "RSA withdrawal" specifies decreasing RSA activity during task activity compared to baseline RSA, therefore quantifying the inhibition of PNS (Zeytinoglu et al., 2020). The **heart pre-ejection period (PEP),** defined as the time between left ventricle depolarization and blood release from it, serves as an SNS activity indicator (Forouzanfar et al., 2019) with shorter PEP considered to be sympathetic activation (Fanti et al., 2019).

Children

Tenenbaum et al. (2019) examined RSA and PEP in 75 children with ADHD compared to healthy controls during neutral and emotional Go/NoGo tasks. Although the children with ADHD and the healthy controls did not differ in baseline PEP and RSA, a significant difference in both measures occurred during both neutral and emotional Go/NoGo tasks across task conditions. Specifically, the children with ADHD showed longer PEP during Go/NoGo tasks (i.e., sympathetic inhibition); healthy individuals showed shortened PEP (i.e., sympathetic activation). Children with ADHD showed higher RSA (i.e., parasympathetic activation) than healthy controls.

A study of preschool children (Zeytinoglu et al., 2021) aimed to create typical profiles based on their RSA withdrawal (i.e., parasympathetic inhibition; Zeytinoglu et al., 2020) and pre-ejection period (PEP). A profile observed in approximately 7% of 278 children, characterized by longer baseline PEP (i.e., sympathetic inhibition; Zeytinoglu et al., 2020) and lower baseline RSA, showed the highest PEP shortening and insignificantly lower RSA withdrawal compared to other groups during self-regulation measures. This applied to executive functioning measures, including working memory, inhibitory control (measured by Go/NoGo task), and cognitive flexibility. In other words, children showing higher levels of task-dependent sympathetic activity and task-dependent parasympathetic inhibition, as indicated by low RSA withdrawal and PEP shortening, had the lowest ability in executive functioning, including inhibitory control tasks. It is important to note that RSA and PEP measures were compared to a complete profile, including several variables other than impulsivity. Nevertheless, a focus on creating a typical physiology-based impulsivity profile may be valuable.

Muñoz and Anastassiou-Hadjicharalambous (2011) studied PEP, RSA, and HR in 38 preschool children undergoing a variety of impulsivity/inhibition measures. Commission errors during a Go/NoGo task, cognitive impulsivity measured by a Circle-drawing task, and behavioral impulsivity scaled by professional observers and caregivers were measured. Children with high impulsivity showed baseline lower HR and higher PEP. No significant differences were observed for RSA. In a study of 50 non-clinical children, Bennett et al. (2014) found that the lower the HR, the higher the impulsivity as measured by commission errors in a Go/NoGo task and parent-reported impulsivity; this confirmed a lower HR at rest for more self-reported impulsive children. Mathias and Stanford (2003) found a negative relationship between HR and self-reported impulsivity in highly attention-demanding tasks. On the other hand, Loheide-Niesmann et al. (2021) examined data from more than 875 adolescents and observed no direct association between self-reported impulsivity (as measured by the Substance Use Risk Profile Scale; Woicik et al., 2009) and RSA or HR, while HR was negatively associated and RSA positively associated with self-reported sensation-seeking, suggesting it is important to distinguish between impulsivity dimensions.

Adults

According to most studies in healthy adult people (Allen et al. 2009; Herman et al., 2019; Vogel et al., 2017), there is no relationship between HR, RSA, and PEP in resting state and impulsivity as measured by self-reported impulsivity questionnaires or rating scales. At the same time, Allen et al. (2009) found a negative relationship between HR and impulsivity (measured by BIS-11) during speech preparation in men and speech production in women in 101 healthy people. Xing et al. (2020) showed a negative association between RSA and behavioral inhibition measured by a Go/NoGo task. Moreover, Puttonen et al. (2008) examined data from more than 1300 adult individuals and found that the impulsivity dimension of sensation seeking was negatively associated with HR and positively associated with heart-period variability, with the effect of heart-period variability diminishing after controlling for risk behaviors such as alcohol use and smoking.

Generally, HR, RSA, PEP, and other ANS-based measures have been used more frequently for studying impulsivity, inhibition, and other ADHD symptoms over the last ten years. Even though the results are scarce and, in some cases, contradictory, the growing interest in this area is obvious. Finding physiological ANS-based correlates of impulsivity or ADHD, in general, would highly improve its diagnostical process. Nevertheless, as these measures may be associated with other psychiatric domains, such as emotional regulation (Tenenbaum et al., 2019), the challenge of establishing their possible discriminatory function still lies ahead.

16.4.2 Transcranial Magnetic Stimulation

Transcranial magnetic stimulation (TMS) is a non-invasive brain stimulation method for altering the functioning of specific brain regions and thus providing an alternative treatment method for various psychiatric disorders (Guo et al., 2017). TMS-based paired-pulse protocols (ppTMS) have recently been used to assess brain function, including inhibition/excitability mechanisms and connectivity (Hui et al., 2019). ppTMS uses two consecutive pulses with specific strengths and relative timing parameters while measuring responses using EMG or EEG channels. Among the many ppTMS protocols, **Short Interval Cortical Inhibition (SICI)** is considered to reflect GABAergic brain activity (Harris et al., 2021; Ziemann et al., 2015), possibly providing a neurophysiological marker of inhibition and impulsivity. In SICI, local GABAergic interneurons are activated by the first (conditioning) pulse, which causes response inhibition in the second (conditioned) pulse occurring approximately 2–5ms later. A typical response decrease for the conditioned pulse is recorded when compared to the single same-intensity pulse.

ADHD Patients

Bunse et al. (2014) provided a systematic review of SICI in ADHD and consistently reported SICI reduction in children with ADHD compared to healthy controls. Adults with ADHD showed a less clear pattern with generally lower SICI than HC. Similarly, Dutra et al. (2016) conducted a meta-analysis on five studies concerning the relationship between ADHD and SICI. ADHD populations showed generally lower SICI levels than healthy controls in adults and children. SICI reduction in children with ADHD was recently replicated by further studies (Detrick et al., 2021; Gilbert et al., 2019; Harris et al., 2021). A significant negative association between SICI and ADHD remained constant during rest and behavioral inhibition conditions. In addition, Harris et al. (2021) observed a negative association between GABA+ levels and SICI across samples pointing toward an unspecified but general SICI mechanism. In children with ADHD, a positive relationship between self-reported/observer ADHD symptom severity and SICI was documented (Gilbert et al., 2011; Hoegl et al., 2012). Generally, the evidence for SICI alterations in children with ADHD tends to grow rapidly. More data is needed to assess the adult ADHD population.

Impulsivity and Inhibition

A higher ability to inhibit response during behavioral inhibition tasks is significantly positively correlated with SICI (Chowdhury et al., 2019), and individuals with a better ability to inhibit responses show significantly higher levels of SICI than individuals with a lower inhibition ability. Those with better behavioral inhibition ability show increased SICI during the inhibition condition (stop condition); individuals with lower behavioral inhibition do not show such effects. Moreover, Chowdhury et al. (2020) even showed the possibility of strengthening SICI after behavioral inhibition training with simultaneous inhibition improvements in individuals, but not at the overall group level. Chowdhury et al. (2018) studied impulsivity in at-risk gamblers and healthy individuals and showed a strong positive association between behavioral impulsivity measures and SICI for both groups; SICI simultaneously served as a significant predictor of overall behavioral impulsivity results. On the other hand, SICI was not associated with reaction times or fewer stopping errors. In addition, behavioral inhibition deficits have been demonstrated in autism spectrum disorder (Uzefovsky et al., 2016). Lower SICI is generally found in other impulsivity and inhibition-related psychiatric disorders such as obsessive-compulsive disorder, Tourette's syndrome, and dementia (Bunse et al., 2014; Mantovani et al., 2013; Radhu et al., 2013) as well as in both acute manic and remitted first-episode mania patients when compared to healthy controls (Basavaraju et al., 2017). Finally, it was negatively associated with motor activity (Ruiz-Veguilla et al., 2016). These results point toward diminished SICI more as a transdiagnostic impulsivity/inhibition construct than a specific ADHD marker. Nevertheless, SICI alterations have also been observed in schizophrenia and major depressive disorder (Kinjo et al., 2021; Radhu et al., 2013). More robust research is needed to establish exclusivity as a neurophysiological marker of inhibition or impulsivity.

Other TMS-Based Neurophysiological Markers

A possibly antagonistic marker referring to glutamatergic neurotransmission, called **intracortical facilitation (ICF)**, is mainly studied as a neurophysiological indicator of excitability and may be viewed as a complementary mechanism to SICI (Ziemann et al., 2015). SICI and short ICF (SICF) tend to interact (Ding et al., 2021). ICF generally reflects higher excitability in impulsivity-related disorders, albeit less consistently than SICI (Bunse et al., 2014; Radhu et al., 2013). ICF was linked to inattention in the psychiatric population (Pedapati et al., 2019). A meta-analysis (Dutra et al., 2016) resulted in no significant differences in ICF for children and adults.

16.4.3 Eye Blink Rate

Eye blink rate (EBR) and spontaneous EBR have been repeatedly linked to dopaminergic (DA) brain activity, mainly to D1 and D2 receptors. EBR has a significant association with DA changes (Jongkees & Colzato, 2016; Karson, 1983) and is therefore useful for studying DA-related brain processes and disorders. DA seems to influence cognitive functioning including inhibitory control, attention control, and other related processes (Unsworth et al., 2019). The association of EBR with both impulsivity/inhibition and inattention, with regard to different impulsivity facets and their relevance to DA brain activity, have been studied repeatedly (Byrne & Worthy, 2019; Maffei & Angrilli, 2018). As EBR is a non-invasive and easily managed approach, establishing such physiological markers of impulsivity or inattention would be highly beneficial.

Inhibition/Impulsivity

Zhang et al. (2015) observed a positive relationship between EBR and behavioral inhibition measured by Go/NoGo and Stroop tasks, specifically higher EBR related to improved Go/NoGo results and lower inhibition costs during the Stroop task in healthy individuals. Similarly, Korponay et al. (2017) measured both behavioral and trait impulsivity in 127 healthy adults. Higher EBR was positively associated with Go and NoGo accuracy representing lower behavioral impulsivity. During a non-rewarded phase of a behavioral inhibition task in substance-abusive individuals, Byrne and Worthy (2019) found neither trait disinhibition nor EBR alone to be predictors of behavioral inhibition. Nevertheless, during the rewarded phase, an interaction between EBR and substance use became a significant predictor of behavioral inhibition: individuals displaying lower EBR became less inhibited. In this study, EBR itself shared only an insignificant correlation with behavioral inhibition. This is in line with previous findings by the same authors (Byrne et al., 2016) with a similar population. Here higher disinhibition/impulsivity predicted poorer behavioral inhibition only for low EBR individuals, while EBR itself was not significantly associated with trait or behavioral impulsivity/disinhibition measures.

By contrast, a study by Huang et al. (1994) was one of the first to link EBR to impulsivity; it reported the opposite results. In a study of 109 prisoners without psychiatric conditions and 45 controls, self-reported motor impulsivity shared a positive relationship with EBR during an oddball task. Similarly, Colzato et al. (2009) observed longer stop-signal reaction times in higher EBR, showing a negative relationship between behavioral inhibition and EBR. Stebbins et al. (2021) observed EBR as a positive mediator between sleepiness and impulsivity during negative NoGo conditions as well as a significant correlation between EBR and behavioral impulsivity during negative NoGo conditions. Similarly, Buitenweg et al. (2021) reported EBR not predicting response inhibition during SST in older adults before or after cognitive training.

ADHD Patients

Results in ADHD individuals are scarce and mixed. Baijot et al. (2016) found higher EBR in children with ADHD compared to typically developing ones; Konrad et al. (2003) presented lower EBR in children with ADHD and traumatic brain injury. Tantillo et al. (2002) observed no baseline difference between girls and boys with ADHD and HC, but a significant EBR increase in boys with ADHD but not girls with ADHD or HC after maximal physical exercise and bringing sex and physical activity variables into account. Two other studies reported no association between EBR and general ADHD symptomatology or different EBR levels between ADHD and non-ADHD probands (Groen et al., 2017; Unsworth et al., 2019). More studies will be required to establish robust results in the ADHD population.

16.4.4 Conclusion: Neurophysiological Impulsivity Measures

Researcher interest in exploring neurophysiological correlates of impulsivity is growing, and various types of neurophysiological measures have been linked to different impulsivity dimensions and measures. At the same time, the current evidence of physiological impulsivity correlates and ADHD symptomatology is insufficient. Regarding autonomous nervous system measures, evidence is growing for a positive relationship between respiratory sinus arrhythmia and impulsivity in children or an opposing trend between individual heart rate and impulsivity in both children and adults. Using transcranial magnetic stimulation in order to quantify brain inhibitory mechanisms seems like a very promising and fairly reliable approach, and the existing research congruently shows a negative relationship between SICI and impulsivity/ADHD symptoms (i.e., the lower the SICI, the higher the impulsivity including ADHD symptoms). Finally, optometric studies focusing on dopaminergic neurotransmission such as blink rate measures bring new insight into impulsivity research. Further developing, specifying, and improving these methods in terms of reliability may promote our understanding of impulsivity mechanisms and yield new possibilities for impulsivity treatment. For these reasons, researchers are strongly supported in correlating neurophysiological measures with measures of impulsivity and measures of specific impulsive behaviors.

16.5 Conclusions

Impulsivity is a heterogeneous and multidimensional construct that can be measured by various methods and tests. In this chapter, we have described self-reported and rating measures of impulsivity, behavioral tests of impulsivity, and innovative neurophysiological methods of impulsivity measuring. Among self-reported questionnaires, the Barratt scale and UPPS-P model are the most widely used. The Barratt scale use should be careful due to its questionable factor structure. The UPPS-P model includes dimensions Deficits in Conscientiousness, Sensation seeking and Urgency, the tendency to act impulsively under the influence of emotions. Rating scales and clinical interviews focusing on ADHD symptoms are not suitable for measuring impulsivity per se since impulsivity is typically mixed in one score with hyperactivity. Among behavioral tests, we can distinguish tests of behavioral inhibition and preference for immediate reward. Behavioral inhibition tests can be further divided into tests of action withholding (measures mainly by Go/NoGo tasks and Continuous Performance tests), action stopping (measures mainly by Stop-signal tasks), and interference control (measure mainly by Stroop, Simon, Flanker, or Antisaccade tests). Preference for immediate reward (or delay aversion) is typically measured by Delay or Probability discounting tasks. The behavioral tests bring the opportunity to measure and compare specific impulsivity-related functions and create impulsivity profiles that can distinguish clinical populations. Task parameters can be easily modified, and the tests can be used tailored to the desired context. At the same time, behavioral impulsivity test results are strongly influenced by many task and participant characteristics which need to be considered when using the tests. Finally, neurophysiological measures of impulsivity based on the autonomous nervous system, transcranial magnetic stimulation, or eye blink rate have been developed. In the future, neurophysiological measures can uncover impulsivity markers and bring new opportunities for impulsivity treatment.

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17 School-Based Interventions and Accommodations for ADHD

Benjamin J. Lovett, Katie Fitzgerald, Theresa M. Schaberg, and Jason M. Nelson

17.1 School-Based Interventions and Accommodations for ADHD

Children and adolescents with attention-deficit/hyperactivity disorder (ADHD) typically show functional impairment in a wide variety of settings, but often a referral for diagnosis or treatment comes due to impairment at school. DuPaul and Langberg (2015) reviewed the academic impairment associated with ADHD, finding that even in preschool, children with higher levels of ADHD symptoms (particularly inattention) have lower levels of early literacy skills. In elementary school, students with ADHD exhibit lower academic skills, lower levels of on-task behavior in school, and trouble with organizing school materials, particularly homework. In high school, these problems continue, and they become more severe as teachers expect more independent work on the part of students and there are fewer opportunities to catch up. Therefore, it is perhaps not surprising that ADHD is associated with more failed classes, higher rates of school drop-out, and lower rates of attending a four-year college.

In this chapter, we review the research literature on school-based strategies for managing the impairment associated with ADHD. As an organizing heuristic, we use the life-course model of ADHD management proposed by Evans et al. (2014; see also DuPaul et al., 2020). The life-course model involves four stages of strategies that can be implemented sequentially. In the first stage, a foundational framework for service delivery is set up. Practitioners ensure that the child's home environment is safe and supportive and that parents or guardians have lines of communication with teachers and other school staff as needed. A brief assessment may find all this already in place, but if it is not, it is set up if at all possible before moving on. Because such a framework is rarely sufficient for treating ADHD, a second stage typically occurs, involving the implementation of various specific psychosocial interventions targeted to functional impairment in different settings. If these are insufficient or (occasionally) simply not feasible, a third stage occurs, involving prescribed medication that directly reduces ADHD symptoms. If psychosocial and medical interventions have been implemented with integrity and care, and the student continues to show significant impairment, a fourth stage occurs, involving accommodations.

The general rule of the life-course model is "interventions before accommodations," and the reason is clear: our goal, when working with children and adolescents with ADHD, should be to set them on the path toward independence in adulthood. Interventions have the potential to build skills allowing for later independence, so

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that supports are eventually not necessary. In contrast, implementing accommodations within the life-course model essentially admits that it is not possible to improve certain skills in a student with ADHD, and so instead, tasks must be modified to fit the student's existing skill levels. The life-course model is reminiscent of Reinhold Neibuhr's famous serenity prayer, asking for "grace to accept with serenity the things that cannot be changed, courage to change the things that should be changed, and the wisdom to distinguish the one from the other" (quoted in Sifton, 1998, p. 16). Whenever skill levels can be changed (i.e., improved), we should have the courage to implement interventions; when skill levels cannot be changed, we must accept this with serenity and pivot to accommodations.

A recent randomized controlled trial (RCT) provides support for the life-course model's preferred ordering of strategies. Harrison et al. (2020) directly compared two groups of middle school students with ADHD; one group received a package of interventions related to planning, organization, and other executive function problems, whereas the other group received a package of accommodations related to the same issues. For instance, whereas one group received a copy of class notes, the other group was taught note-taking strategies. The RCT found that at the end of the study, students who received interventions improved their skills, whereas those who received accommodations did not. Although these results may not be surprising, accommodations are often provided without any consideration of their long-term impacts (Arnold, 2021).

In recent years, the percentage of K-12 students receiving special education services under the "other health impairment" category (often, mainly ADHD) has been rising steadily (National Center for Education Statistics, 2021). Over 1 million US children are now served under that category, constituting over 15% of all students receiving special education and over 2% of total public school enrollment. Many other students with ADHD are served under Section 504 plans, which prevent a student from being discriminated against due to disability. Section 504 plans generally only include accommodations, whereas special education services (provided under Individualized Education Programs, IEPs) typically include specialized instruction with separate, individualized academic and/or social/behavioral goals, in addition to any needed accommodations. Interestingly, research suggests that accommodations are more common than evidence-based interventions in school settings for ADHD (e.g., Spiel et al., 2014). Indeed, Lovett and Nelson (2021) concluded that accommodations are likely to be the most frequent response to ADHD in schools, which raises the question of whether the philosophy of the life-course model is being widely followed. Nevertheless, in this chapter, we cover the two types of strategies in the order suggested by the life-course model, starting with interventions and then moving to accommodations. Also consistent with the model, we devote more space and detail to the interventions.

17.2 School-Based Interventions for Students with ADHD

We searched the research literature to determine which interventions, specifically those designed for the school environment, have been found to improve ADHD-related impairment in school-aged children. The most extensive research has been conducted on direct intervention and home/school collaboration with middle school and high school students, as older children appear to respond best due to their increased cognitive control. Many of these programs target outcome measures such as teacher- and parent-rated organizational, time management, and planning (OTMP) skills, as well as objective measures such as grade point average (GPA) and percentage of completed assignments. Despite similarities in targeted outcomes, these programs differ by degree of structure, intervention content, and delivery method.

17.2.1 Homework, Organization, and Planning Skills (HOPS) Intervention

One of the areas most impacted by ADHD in school-aged children is homework completion. The Homework, Organization, and Planning Skill (HOPS) intervention was developed with the planning and organizational aspects of homework completion in mind, specifically for students with ADHD. Delivered by school mental health (SMH) providers, typically school psychologists or school counselors, HOPS is a brief (16 sessions) program completed within a single school semester, with each session lasting for a maximum of only 20 minutes. Notably, SMH providers can feasibly implement the intervention during the school day, given the brevity of the sessions. Initial sessions generally target homework recording and management skills (e.g., how to use a planner to consistently and accurately record assignments, tests, and projects) and materials organization (e.g., a system of binder, backpack, and locker organization; an organization system for transferring necessary materials to and from school). Later sessions address time management and planning (e.g., how to break up studying for tests and large assignments into smaller, more manageable units; how to plan for timely completion of each unit; how to plan out evenings and extracurricular activities to have adequate time to complete school responsibilities). Students are reinforced on a point system (e.g., timely homework completion earns one point) and rewarded for consistent implementation of learned skills via a rewards menu developed by the SMH provider. Ideally, each of these skills is taught during the first 10 sessions, which are condensed into 5 weeks (two sessions per week), after which sessions move to once weekly to address self-monitoring and maintaining skills, as well as other problem-solving difficulties. In addition, two one-hour meetings are held with caregivers and students to teach them tools to promote similar skills at home.

Langberg et al. (2012) found that among a sample of 47 sixth through eighth graders with ADHD, those assigned to participate in the HOPS intervention ($n = 24$) had higher grades post-intervention, as well as significantly greater improvements in parent ratings of task planning ($d = 1.05$), "organized actions" (use of tools and strategies for organization; $d = 0.88$), and homework completion behaviors ($d = 0.85$) relative to those in a waitlist group. Furthermore, post-intervention parent ratings revealed a greater decrease in inattention symptoms ($d = 0.52$) compared to students on the waitlist. These improvements, as measured by parent ratings, were sustained at a three-month follow-up. However, no significant differences were found between groups on changes in teacher ratings of organizational skills and homework problems.

In a later study assessing the importance of skills learned by adolescent and parent participants from the HOPS intervention, as well as predictors of intervention response, Breaux et al. (2018) sampled 111 students with ADHD who had received the HOPS intervention in seven public middle schools. Specifically, the researchers examined the acquisition of OTMP skills among adolescents (e.g., bookbag organization, homework recording, assignment planning), parent implementation of monitoring and reinforcing OTMP behaviors, and how these factors predicted intervention outcomes. These outcomes included post-intervention parent and teacher ratings of homework problems and organizational/time management skills, and the objective measure of student grade point average (GPA).

Regression analyses, when controlling for baseline variables, found that the acquisition of OTMP skills varied in the prediction of post-intervention outcomes (Breaux et al., 2018). With respect to parent-reported outcomes of homework problems and organization, the acquisition of all three OTMP skills (organization, time management, and planning) predicted improved homework performance ($\beta s = 0.27–0.38$) and lower ratings of organizational problems ($\beta = -$

0.25). In contrast, none of the OTMP skills predicted teacher-rated homework problems and only acquisition of time management skills predicted lower teacher-rated organizational problems ($\beta = -0.29$). Acquisition of the three OTMP skills predicted improvement in assignment completion (βs = 0.21). Together, the acquisition of all three OTMP skills and one parent skill, specifically the use of rewards and consequences for OTMP behaviors, significantly predicted improvement in student GPA (βs = 0.20–0.33) but were not found to be significant unique predictors.

With regard to the efficacy of the HOPS intervention, Breaux et al. (2018) found that the majority of students demonstrated significant improvement in backpack and binder organization, as well as the strong acquisition of accurate homework recording (75%) and organizational skills (76.4%), whereas one-quarter of the sample was classified as "non-responders" to OTMP skills training. Overall, these results indicate that the acquisition of all three skills taught during the HOPS intervention are significant predictors of intervention outcomes, while demonstrating that the improvement in outcomes appears to be independent of parent skills implementation.

17.2.2 Completing Homework by Improving Efficiency and Focus (CHIEF)

Completing Homework by Improving Efficiency and Focus (CHIEF) is a similar homework intervention program that focuses on the behavioral components of homework completion. Unlike the HOPS program, CHIEF focuses more on reinforcement of desired behaviors rather than skills acquisition, as some students with ADHD have the skills necessary to organize and plan to complete homework, but require more structure in their schedules in order to complete assignments. The CHIEF intervention utilizes the same service delivery design as HOPS (i.e., 16 sessions over one semester and two parent meetings); however, a behavior management program is implemented utilizing a point system in order to set work completion goals and to encourage students to study for exams and complete homework assignments. Through consultation, parents and caregivers are guided in how to implement a similar point-based behavior system at home, targeting how to set clear work completion goals and deadlines with a focus on encouraging sustained attention and efficiency in work completion.

An analysis of both these programs suggests considering the student's behavioral presentation and severity of executive functioning (EF) deficits when choosing which program is more likely to be beneficial for individual students. Langberg et al. (2018) conducted the first empirical evaluation of the CHIEF intervention in a comparison study of CHIEF and HOPS interventions in middle school students (grades six through eight) against a waitlist control group. Across a three-year period, 111 students were given the CHIEF intervention, 111 were given the HOPS intervention, and 52 were placed on a waitlist with no intervention. OTMP outcomes of homework completion, homework materials management, and organizational skills, as well as parent satisfaction were assessed via rating scales completed by relevant stakeholders (i.e., parents, teachers). These outcomes, paired with student GPA, were compared across groups at three time points: pre-intervention, post-intervention, and at six-month follow-up. In relation to baseline performance and waitlist controls, significant effects were found post-intervention in both CHIEF and HOPS groups for organization and homework outcomes (CHIEF *d*s ranged from 0.57–1.08; HOPS *d*s ranged from 0.79–1.27), and these gains were maintained at six-months post-intervention. Notably, there was no significant change in GPA across groups and the effect size was negligible in range ($\eta_p^2 = 0.01$). HOPS and CHIEF groups demonstrated comparable outcomes on measures of focus and efficiency during work completion compared to waitlist controls, with the most significant gains seen in students with the least severe pretest behavioral symptomatology. In general, HOPS participants made significantly greater improvements in parent and teacher ratings of organization actions

($ds = 0.68$) as compared to students in CHIEF ($ds = 0.43$), although no differences were found across intervention groups for ratings of homework problems. However, moderation analyses revealed that, for students who had more severe psychopathology and EF impairment, the HOPS intervention led to significantly greater improvements in ratings of homework problems and organizational skills as compared to the CHIEF intervention. The results from this study suggest that both HOPS and CHIEF can be used to improve associated homework problems in middle school students with ADHD. However, the HOPS intervention may be preferable for those students with more severe symptomatology.

17.2.3 Challenging Horizons Program (CHP)

Another school-based intervention that has been studied in middle school students with ADHD is the Challenging Horizons Program (CHP). CHP is a multicomponent intervention that focuses on training organizational skills, interpersonal skills, and homework management. CHP is unique among school-based interventions in its duration, lasting for an entire school year rather than for a set number of sessions.

Evans et al. (2016) assessed the effectiveness of two forms of CHP in 326 middle school students (grades six through eight) with ADHD: CHP-after-school version (CHP-AS) and a mentoring version (CHP-M), against a treatment-as-usual control group (CC). The CHP-AS ($n = 112$) program took place after school 2 days per week during the school year, with sessions lasting 2 h and 15 min and involving 6 to 10 students. During these sessions, students engaged in five core activities, including an individual meeting between the student and their trained undergraduate student counselor (primary counselor time), group social skills intervention (ISG), education/study skills (education group), individual homework completion (individual education time), and time for games and/or recreation (recreation time). In addition to these after-school sessions, three parent meetings were held throughout the school year to provide psychoeducation about ADHD and the interventions applied during CHP-AS.

Students within the CHP-M treatment group ($n = 110$) received intervention from a school-teacher or staff member (mentor) during the school day (e.g., homeroom, lunch, study hall, before classes) rather than after school. These meetings, as in sessions for the CHP-AS program, involved interventions targeting organizational skills, homework recording, daily report cards (DRCs), assignment checks, and study skills. In addition to these one-to-one sessions with students, mentors met with their consultant bi-weekly (a trained doctoral psychology student) to review student data and provide guidance regarding intervention modifications.

Students randomized to be in the control group ($n = 104$), received a list of local resources available at the beginning of the school year. This list was developed collaboratively with school staff and local providers, such that families might have access to psychosocial and pharmacological intervention options outside of the school.

At follow-up, CHP-AS was found to provide moderate improvement in the organizational measures of task planning ($d = 0.57$) and memory/materials measurement ($d = 0.55$) in comparison with the CC group. When compared to CHP-M at follow-up, CHP-AS demonstrated similar improved ratings on task planning ($d = 0.58$) and memory/materials management ($d = 0.40$), as well as improvements on the third organizational measure, organized actions ($d = 0.36$). No significant differences were found post-intervention or at follow-up between CHP-M and CC groups. With regard to academic functioning, no significant differences were found between groups at either time point.

Students in the CHP-AS group were found to have greater improvement ratings of inattention symptoms at post-intervention ($d = 0.51$) and follow-up ($d = 0.61$) compared to the CC group. While no significant difference was found between CHP-AS and CHP-M groups at postintervention, CHP-AS showed significantly greater improvement on inattention ratings at follow-up ($d = 0.55$). Again, no significant differences were found between CHP-M and CC groups on ratings of inattention at either time point. Finally, the outcome of homework problems was subdivided into two factors: inattention and avoidance of homework (Factor 1) and poor productivity and non-adherence with homework rules (Factor 2). At both post-intervention ($d = 0.44$) and follow-up measures ($d = 0.61$), CHP-AS students had superior ratings for both factors in comparison with the CC group. Although no significant differences were found post-intervention between CHP-AS and CHP-M students, follow-up measures revealed significant improvements in CHP-AS students compared to CHP-M students on Factor 1 of homework problems ($d = 0.49$). A comparison of CHP-M and CC groups post-intervention found improvements favoring CHP-M students on Factor 2 ($d = 0.31$); however, these differences were not maintained at follow-up.

DuPaul et al. (2021) assessed the effectiveness of CHP delivered during the school day in 186 high school students with ADHD (grades 9 through 11), both during the treatment year and during a six- to eight-month follow-up. The importance of maintaining treatment goals at follow-up is paramount to stakeholder (e.g., parents, teachers) concerns, which typically prioritize the maintenance of skills gained over time. Of the 186 students sampled, 92 were randomly assigned to receive treatment, while the remaining 94 were assigned to a community care (CC) condition to serve as controls, in which students and parents were given a list of available resources within their community. The CHP model used in this study included individual in-school counseling sessions, monthly collaborative problem-solving sessions with the student and coach, and parent sessions. Students met one-to-one with their coaches twice per week throughout the school year, typically during a free period (e.g., homeroom, lunch, study hall) or an elective class, to foster organization, problem-solving, study, and interpersonal skills. Initial sessions focused on developing an organization system for the student's materials (e.g., binders, folders), as well as tracking assignments in an electronic calendar or planner. Binder and planner checks were built into subsequent sessions to assess the student's adherence to the developed system, during which time the student would practice addressing any disorganization (e.g., update the planner, put assignments in correct folders/binders). On a monthly basis, coaches met with students and reviewed performance in six areas identified for improvement: missing assignments, failing classes, in-school discipline, out-of-school suspension, tardiness, and absenteeism. If, during these check-ins, a student met a predetermined threshold (e.g., 80% or fewer assignments turned in on time), students and coaches would engage in a problem-solving process. Finally, ten 90-min sessions were offered for parents throughout the school year (five in the fall, five in the winter and spring), in which parents received psychoeducation on ADHD and common issues faced by adolescents with this diagnosis.

Regarding treatment fidelity, DuPaul et al. (2021) found that students within the CHP group attended, on average, one session per week, lasting around 15 minutes, throughout the school year. Most absences throughout the study were attributable to school absences, closures due to weather, or in six cases, due to withdrawal from treatment during the year. The average attendance of parent group sessions was 4.3 sessions ($SD = 3.8$), suggesting that parents within the study attended about half of the offered parent sessions.

DuPaul et al. (2021) found that at the end of the school year, students assigned to the CHP treatment group demonstrated significantly better scores in parent-rated organizational skills (ds ranged from -0.40 to -0.58) and homework performance (ds ranged from -0.40 to -0.44) as compared to students in the CC group. These improvements were found at post-intervention and were sustained into the following school year. Additionally, regression analysis revealed steeper slopes for students in the CHP group, suggesting that these students made faster improvements than those in the CC group. Although the difference in grade improvement was minimal across groups, it is worth noting that CHP appeared to protect against a steep decline in grades. Finally, no statistically significant differences were found between groups in adolescent self-reports ($d = 0.38$) or teacher ratings ($d = 0.17$) of academic performance. Overall, these data suggest that CHP leads to improvements in homework performance and organization skills in high school students.

17.2.4 Students Taking Responsibility and Initiative Through Peer Enhanced Support (STRIPES)

Peer-delivered interventions have yielded variable results. A benefit of these peer-delivered programs is that participants may be more receptive and responsive to similar-aged peers delivering an intervention rather than unfamiliar adults doing so. STRIPES (Students Taking Responsibility and Initiative through Peer Enhanced Support) is a low-burden, peer-delivered intervention developed from pre-existing executive skills training interventions for middle school students, and later adapted for a high school population as well. Over the course of 16 weeks, weekly 30-min meetings are held in a STRIPES teacher-sponsor supervised group setting between two middle school or high school students and one peer interventionist. During the initial session, students set long-term goals that they track and discuss with their peer interventionist during subsequent weekly sessions. Targeted skills include managing and organizing materials, accurately writing down assignments in a daily planner, time management and assignment/homework planning, reviewing grades and assessing recent performance, and problem-solving areas of concern. Students also work to set weekly short-term goals that support their devised long-term goals. Peer interventionists, who are nominated by their teachers for demonstrated strong academic performance and organizational skills, are trained to provide positive feedback and reinforcement for one constructive action taken by the student each week.

Sibley et al. (2020), in assessing the feasibility of implementing STRIPES in a real-world school environment, found that students enrolled in the program and peer interventionists both experienced bonding and positive enjoyment during the program, as well as overall positive satisfaction. Goal setting, reviewing weekly goals, managing materials, and planning homework were rated to be the most helpful target skills by students in the program, whereas using the daily planner and time management interventions were rated as least helpful. Students indicated that the helpfulness of the intervention and spending time with their peers were the greatest benefits of the program, while other commitments and forgetfulness emerged as the primary barriers to engagement. The most common suggestion for improvement was to deliver the program during the school day, rather than after or before school. Notably, while students on both sides of the program (participants and interventionists) reported enjoyment and positive outcomes from the program, the intervention data did not meet the researchers' fidelity metric. Attendance data indicated that the average student in the program attended 5.38 ($SD = 5.30$) of 16 offered sessions, whereas the average peer interventionist attended 15.50 sessions. Fidelity checklists indicated a range of 75–83.3% compliance in students working toward program goals. As indicated by participant suggestions for improvement, this failure to meet the feasibility metric may stem from poor fit with the developmental stage, as high school students likely have greater extracurricular responsibilities than elementary or middle school students. Thus, the data suggest that the STRIPES model may be more effective among high school students with ADHD if offered as part of the school day to overcome barriers to sufficient attendance.

In order to address the issue of feasibility, Sibley et al. (2020, Study 2) conducted a subsequent study of STRIPES student outcomes ($N = 72$) with the added variable of the delivery model. Three models were implemented across three high schools: after-school delivery (HS1), as implemented in the above study; pull-out delivery (HS2), where peers pulled students from an elective class for 30 min per week; lunch-delivery (HS3), in which students participated in STRIPES intervention meetings during lunch once per week. All three intervention groups ($n = 36$) were compared with a monitored control group without intervention ($n = 36$).

With regard to feasibility, results indicated a statistically significant difference in attendance between different provision models. Overall, students within the pull-out delivery group (HS2) demonstrated higher average session attendance ($M = 8.42$, $SD = 1.78$) than students at HS1 receiving intervention after school ($M = 3.50$, $SD = 2.43$) and those in HS3's lunch model ($M = 4.458$, $SD = 4.66$). However, no differences were found across delivery models for peer interventionist attendance.

Students in STRIPES treatment groups across sites experienced a smaller decline in ratings of bookbag organization over time as compared to those in the control groups, suggesting that the STRIPES intervention is protective against worsening organizational skills regardless of delivery method. Group differences also emerged regarding academic interest, as students in the STRIPES pull-out model (HS2) demonstrated small improvements over time ($d = 0.23$), while those in the control group showed a steep decline in the perceived importance of academics ($d = -1.46$). Students in HS2 also showed improvement in academic self-confidence ($d = 0.23$) and willingness to try one's hardest ($d = 0.55$), while those in the control group demonstrated medium to large declines in these outcomes over time ($d = -0.62$; $d = -1.50$). These group differences, however, did not emerge between controls and students in STRIPES after-school (HS1) and lunch-delivery (HS3) models. The results of these two studies indicate that context-specific delivery impacts the efficacy of the STRIPES intervention for high school students with ADHD, as intervention delivered in a pull-out model during the school day is the most likely to lead to intervention fidelity, as well as positive long-term student outcomes.

17.2.5 Collaborative Life Skills (CLS)

Pfiffner et al. (2011) developed the Collaborative Life Skills (CLS) program in an attempt to integrate school, parent, and student treatments delivered by school-based mental health providers (SMHPs). The program adapted the clinic-based Child Life and Attention Skills Program (CLAS) to fit the school environment, adding simultaneous clinician-teacher-family meetings to support each participant in their role to bring about positive behavioral change and skill acquisition in children with ADHD in grades two through five (7–11 years of age). This program progresses over the course of 12 weeks, with school, parent, and student treatments delivered within both the school and home setting. The school component, involving mental health providers and teachers, includes one SMHP-led orientation, followed by a series of SMHP and teacher consultation meetings reviewing Classroom Challenges to facilitate behavioral modification. These challenges include a school-home DRC targeting individualized problem behaviors which are developed in the first consultation meeting, and a homework plan if needed. This report card is implemented daily, with skill instruction on behalf of the teacher to assist students in earning stars for meeting individualized behavior goals. These stars may be exchanged for daily home rewards and are praised in a child group component each week for group-based reinforcement. Additional classroom supports, such as preferential seating, targeted use of praise, and consistent prompting, may be implemented as needed on an individual basis.

To enforce consistency across school and home environments, parents of children in the CLS program have their own curriculum for implementing the Home Challenge. This Home Challenge, similar to the Classroom Challenges, is a token economy in which students can earn stars for parent-selected target behaviors at home. Parents are taught skills to effectively reinforce these behaviors over the course of 10 group parent sessions, such as how to improve homework routines, organization and independence in the execution of home tasks, and peer interactions in their children. These group sessions also provide parents with skills to appropriately use commands, rewards, and discipline, as well as how to manage their own parent stress. Finally, parents are encouraged to attend up to five SMHP-teacher meetings over the course of the 12 weeks to increase understanding of their child's progress in the classroom setting.

The child skills component of the CLS program involves two curriculum modules, namely, social skills and independence, aiming to address common ADHD-related deficits. The social skills module is delivered first, with emphasis on being a good sport (e.g., following directions, taking turns, using kind words), accepting consequences, problem-solving, self-control, and friendship-making skills. The independence module includes a curriculum regarding homework skills, independence in completing household tasks, and establishing and following routines. These two modules are delivered in ten 40-min group sessions throughout the 12 weeks.

Pfinner and colleagues' (2011) seminal study provided evidence supporting the positive impact of the CLS program within the school setting. Compared to pretreatment measures, students in second through fifth grade (ages seven to 11 years) referred to the CLS program ($n = 37$) demonstrated improvement in ADHD symptoms ($d = 0.83$), related behavior problems ($d = 0.68$), and organizational skills ($d = 0.78$). Further, these improvements were found to be consistent with those seen in students receiving the non-adapted CLAS program in a clinical setting, suggesting that the adaptation to the CLS program was adequate in maintaining efficacy across settings. These preliminary results reinforced the value of simultaneous parent, teacher, and student intervention components, as well as the ability to successfully implement comparable adapted interventions within the school setting.

In a subsequent study, Pfiffner et al. (2016) reinforced these preliminary findings using a RCT of the CLS program in comparison with usual services within a large school district. One hundred and thirty-five students in grades two through five ($M = 8.4$ years) were randomly assigned to either the CLS program or usual services, with a difference-in-means comparison at post-treatment. Results indicated that students assigned to CLS had significantly greater improvement on parent-rated ($d = -1.05$) and teacher-rated ($d = -0.67$) measures of ADHD symptom severity, organizational impairment (parent report $d = -1.09$; teacher report $d = -0.68$), and parent ratings of interpersonal skills (parent report $d = 0.39$) as compared to the control group. This study supported the superior efficacy of CLS as compared to typical school services for improving ADHD-related school impairment, as well as providing promise for improving access to evidence-based treatment beyond the clinical setting.

In a final study, Pfiffner et al. (2016) examined the sustained effects of the CLS program on ADHD symptoms and related school impairment. Using a randomized cluster design, schools within a large, urban public school district (grades two through five) were assigned to CLS or usual services to address ADHD symptoms. It was found that students at schools assigned to the CLS program ($n = 72$) showed significantly greater improvement following a maintenance period of one school year on parent-reported ratings of ADHD symptom severity ($d = -0.95$), organizational impairment ($d = -0.57$), and global impairment than students assigned to usual school services ($n = 62$). However, there were no sustained post-treatment differences between groups on teacher ratings of these measures at follow-up. While this lack of differences in teacher ratings suggests the need for further study of sustained outcomes across school years and new teachers, the sustained significant differences in parent ratings provide support for CLS as an effective intervention for ADHD with long-term outcomes.

17.2.6 Moderators of Efficacy

As discussed above, children with symptoms of ADHD often experience significant impairment in school performance. While the aforementioned interventions have demonstrated varying levels of efficacy in addressing these impairments, research has implicated a number of factors that moderate the success of ADHD interventions within a school-aged population. Social support, co-occurring psychopathology, student emotional engagement, clinician competency and adherence, and parental adherence to intervention have been shown to play a role in intervention efficacy and severity of ADHD-related impairment post-treatment.

In a 2020 study, Green et al. assessed the impact of several social health determinants on the efficacy of school-based ADHD interventions. A sample of 222 adolescents with a diagnosis of ADHD were randomly assigned to receive either the CHIEF ($n = 111$) or HOPS ($n = 111$) interventions, with intervention efficacy measured by the percentage of assignments turned in and teacher and parent ratings of homework performance. These students were further categorized by the social health determinants of income, maternal education, single-parent status, and race to determine any between-group differences in intervention efficacy.

An analysis of students by income indicated that students within higher income households had better parent-reported homework performance following both interventions, although this relationship was less pronounced for students who received the CHIEF intervention (HOPS $d = 0.48$; CHIEF $d = 0.20$), and neither group sustained improvement at the 6-month follow-up measure. There were no significant differences in outcome measures found between groups when parsed out by levels of maternal education. However, an effect was found for single-parent status, with children receiving CHIEF from two-parent households showing significantly higher scores for teacher-rated homework performance at follow-up ($d = 0.79$). Interestingly, this pattern did not appear at follow-up in students who received the HOPS intervention, as no significant differences were found between single- and two-parent households on teacher ratings of homework performance ($d = 0.35$). No significant differences emerged based on parents' marital status at immediate post-intervention for either intervention group. Further, while single- and two-parent households did not differ in the percentage of assignments turned in within the HOPS group, students within the CHIEF intervention group in single-parent households had reduced intervention effects on the percentage of assignments turned in at post-intervention ($d = 0.39$) and follow-up ($d = 0.57$). Analysis revealed a main effect of race for the percentage of assignments turned in ($p < 0.001$) and teacher-rated performance ($p < 0.001$), with white students having higher ratings than black students at all time points throughout the study. These data suggest that while school-based interventions have the potential to decrease ADHD-related school impairment, the effects of these interventions may be moderated by social determinants of single-parent status, race, and income.

Other student health aspects have been implicated in the efficacy of interventions for children with ADHD. For instance, while these interventions target school performance outcomes such as homework completion, organization, and attention levels, many students with ADHD diagnoses have co-occurring psychopathology which may exacerbate commonly seen social deficits. In their study, Morgan et al. (2020) sought to identify factors contributing to varying responses in social skills treatment, examining co-occurring externalizing, depression, and anxiety symptoms in children with ADHD. A sample of 159 children with a diagnosis of ADHD were randomly assigned to participate in the CLS program or to receive usual services, with multi-informant measures of co-occurring psychopathology and baseline social skills collected prior to intervention initiation. Results indicated that parent-rated externalizing and depression symptoms significantly moderated treatment outcomes, with higher ratings of symptomatology predicted worsening social skills in response to usual services, while they had no effect on students in the CLS group. In contrast, teacher-rated anxiety symptoms moderated social skill treatment effects, with higher levels of anxiety predicting greater improvement in social skills in response to CLS, but no significant effect following usual services. These findings reflect the importance of understanding students' co-occurring psychopathology in selecting ADHD interventions when targeting social skills, as comorbid symptomatology significantly moderates treatment response in children with ADHD.

Given that many ADHD interventions are school-based, the role of the school-based mental health provider is crucial to the implementation of treatment content and eventual treatment outcomes. This implementation has been suggested to be composed of three aspects: the working alliance between the client and clinician, clinician adherence to therapeutic interventions, and clinician competence in service delivery. While prior research has demonstrated a positive correlation between the clinician–client relationship and treatment outcomes (Breaux et al., 2018; Langberg et al., 2013, 2016), few studies have investigated the impact of clinician adherence and competence in school-based ADHD interventions. However, Breaux et al. (2021) explored the differential roles of clinician adherence and competency, specifically as predictors for treatment outcomes in the HOPS intervention. The study sample included 107 adolescents with ADHD who participated in the HOPS intervention, with clinician adherence defined as fidelity to session content and length, and competency measured by levels of responsiveness, collaboration, and demeanor. With regard to parent-reported outcomes, clinician competency was found to be moderately negatively associated with organizational difficulties, such that higher clinician competency was associated with less organizational difficulties when controlling for baseline scores and demographics ($B = -0.40$, $p = 0.03$). Similarly, clinician competency emerged as a marginally significant predictor of a higher percentage of assignments turned in post-intervention ($B = 0.30$, $p = 0.01$). In contrast, clinician adherence was largely unrelated to teacher-reported outcomes of organization and percentage of assignments turned in.

Clinician adherence and fidelity to intervention did not correlate significantly with either parent- or teacher-reported outcomes. Interestingly, clinician fidelity and competency were inversely related ($r = -0.34$, $p < 0.001$), as clinicians rated as higher in competency demonstrated less fidelity to the HOPS intervention content. This finding, taken together with results that competency is a significant predictor of treatment outcomes, suggests that more competent clinicians may be more comfortable with adapting session content to the individual student, which in turn may enhance treatment outcomes rather than reduce them. Thus, when implementing these school-based interventions like HOPS, it is imperative that clinicians focus on their competency, or communicated levels of empathy, motivation of the student, and collaboration, while being able to flexibly implement school-based programs to improve ADHD-related school impairment.

Taken together, these identified mitigating factors highlight the multifaceted nature of school-based ADHD interventions. As with all interventions, it is important to evaluate the main effects of treatment to gauge overall efficacy. However, the empirical studies mentioned above demonstrate a number of factors to be considered in the delivery of these interventions.

17.3 Educational Accommodations for Students with ADHD

As we noted above, the life-course model of services for ADHD students suggests that accommodations should only be attempted after interventions have failed, or as a temporary measure while interventions are tried. Although this may be overly conservative in some cases, we certainly concur with the general philosophy of making interventions a default response to ADHD.

17.3.1 Common Accommodations for ADHD

Weyandt and DuPaul (2013) classified educational accommodations for ADHD into four types. First, *presentation accommodations* alter the way that material is presented. This could include providing written instructions for class assignments in addition to orally stating expectations (in case a student with ADHD had difficulty recalling what the teacher had said).

Second, *response accommodations* alter the way in which students are permitted to respond to assignments and exams. For instance, a student with ADHD may be permitted to type essays on a laptop computer during an in-class exam, rather than using their handwriting. Third, *timing and scheduling accommodations* change the time at which an activity takes place or how much time a student is given to do an activity. Additional time to complete exams and assignments would be examples of such accommodations, as would breaks during a lengthy exam. Finally, *setting accommodations* change the environment or place where the student engages in some activity. "Preferential seating," where a student is seated near the teacher, and a small-group administration format for a test, would be examples of these accommodations.

17.3.2 What Makes an Accommodation Appropriate?

When deciding on *interventions*, appropriateness is relatively easy to determine. Generally, an intervention is appropriate if it is effective in raising a student's skill or performance levels, and can be implemented efficiently. In the case of accommodations, things are not so simple. Frequently, school staff will cite, as evidence for an accommodation's appropriateness, the fact that a student's performance levels went up; similarly, staff will often argue for an accommodation by saying that it is likely to raise performance. However, this cannot be sufficient evidence for an accommodation, because accommodations involve altering standards for performance in some way, and so an apparent increase in performance may be due merely to the shift in standards as opposed to a genuine improvement in the student's functioning. Consider a high school student with ADHD who has trouble keeping track of her assignments. An accommodation might involve accepting late work from the student without penalty. If the student's grades rise, the school and family may be pleased, as would the student, but the appropriateness of the accommodation would remain unclear. Advocates of the accommodation might argue that the accommodation allowed the student to demonstrate her skills, but critics would argue that the accommodation led to an unfair boost in performance.

Several criteria have been proposed to determine accommodation appropriateness (Lovett & Lewandowski, 2015; Phillips, 1994). Two criteria are particularly pertinent to the present discussion. One of these criteria is sometimes known as "differential boost," the idea that an appropriate accommodation should differentially benefit students with disabilities, being narrowly tailored to disability-related functional impairment (Fuchs et al., 2005; Sireci et al., 2005). An example of this would be an accommodation for visually impaired students in which tests are printed in very large font size; students with typical visual acuity would likely not benefit nearly as much from the accommodation as visually impaired students would. In contrast, to return to our earlier example, accepting late work without penalty may not show differential boost effects. If an accommodation would benefit everyone equally, it seems unfair to reserve the accommodation just for students with ADHD.[1]

A second criterion that has been suggested is that an accommodation does not compromise the core, essential requirements of a test or academic activity. This comports well with the legal standard (under the Americans with Disabilities Act) that a reasonable accommodation would not involve a "fundamental alteration" to a requirement (Stone, 2006). Again, this is easiest to see in the case of sensory or physical disabilities; if a candidate for a bus driver position were legally blind, it would not be appropriate for the candidate to request, as an accommodation, that someone tell the candidate how to steer the bus. If punctuality and good work habits are part of the skills that high school teachers are hoping to

[1] Indeed, accommodations are seen as desirable by students with *and without* disabilities (Lovett & Leja, 2013), and seeking accommodations is one reason why older students may even exaggerate symptoms of ADHD (Nelson & Lovett, 2019).

instill and reinforce, an accommodation of accepting late work without penalty might be similarly inappropriate. This second criterion implies that an accommodation that is appropriate in one setting may not be appropriate in another. Individual classes and even individual assignments and exams have different goals, and so in each case, decision-makers must consider whether the accommodation would prevent the student from acquiring or demonstrating the skills that are the focus of instruction or assessment.

17.3.3 Research on Accommodation Effects

Research on testing accommodations effects can be very useful, but its utility is somewhat attenuated by two factors. First, much research combines different accommodations and different disability conditions, making it difficult to determine which accommodation and which disability condition is responsible for any observed relationships between accommodation status and educational achievement or test performance. Second, even when a study is specific to students with and without ADHD (as opposed to other disability conditions), the inclusion criteria for entry into the ADHD group can vary greatly from one study to another. For these reasons, it is important to inspect individual studies and also make decisions based on individual student data (a point that we return to later).

The accommodation that appears to have been studied the most is extended time on tests. Lovett and Nelson (2021) located nine studies on the topic. Research has generally shown that students with ADHD improve their performance with extended time, as long as the tests are somewhat time-pressured. However, this accommodation also appears to fail the “differential boost” criterion described above; extended time also helps students without ADHD on the same tests (for literature reviews, see Cahan et al., 2016; Lovett, 2010; Sireci et al., 2005). This does not mean that extended time is never appropriate, to be clear; those students with ADHD who have clear deficits in skills that allow them to access tests under time pressure should receive such accommodations, so long as the tests are not designed to measure speed or fluency. Indeed, research suggests that many K-12 students with ADHD will need additional time to be able to access the same number of test items as nondisabled students can under standard time limits (Lewandowski et al., 2007). However, due to the lack of differential boost, the accommodation should not be given without evidence of individual need. When students who do not need additional time are given extended time anyway, they are likely to choose to take longer to work, and they do not get practice working under time pressure (Pariseau et al., 2010).

Two randomized controlled studies have examined another testing accommodation: tests read aloud. Spiel et al. (2016, 2019) randomly assigned both (a) students with ADHD and (b) nondisabled peers to take typical reading-based tests either under standard test administration conditions or with the test read aloud (in one study, there was a live human reader; in the other study, an audio recording of a human reader was used). Students were 14 years old or younger. In these populations, the test read-aloud accommodation not only benefited students with ADHD, but these students benefited more than their nondisabled peers, meeting the differential boost criterion. It seems likely that for younger students with ADHD who lack attentional focus, having a test reader helps to pace the student and sustain engagement, while also serving as a 1:1 proctor. However, students with ADHD may also have benefited more due to having weaker reading skills than their nondisabled peers (e.g., Sexton et al., 2012). In any case, read-aloud accommodations should be considered for students with ADHD on tests that are not meant to measure reading skills (reading tests in elementary school would typically be excluded from such accommodations approval).

Another common accommodation for ADHD is taking tests in a smaller group or a separate room. The logical basis for the accommodation seems clear; students with ADHD are expected to be more distractible, and a more private setting would include fewer distractions. However, the available evidence for this accommodation is thin and not supportive. Hart et al. (2011) assigned children with ADHD attending a summer treatment program to complete academic worksheets in either a large group or a small group (all students worked individually). The children actually completed more work in the large group setting. It is not clear if the presence of more peers had a motivational or modeling effect, or whether this study sample was unusual (all of the children had ADHD, which is not the case in a typical school classroom). Regardless, the study suggests, at least tentatively, that small group or private room accommodations should not be a default recommendation merely because a student has an ADHD diagnosis. This also converges with results from a study of college students with and without ADHD who took tests under group and private room conditions (Lovett et al., 2019).

There are not many other high-quality studies on educational accommodations for children and adolescents with ADHD (Lovett & Nelson, 2021). It is remarkable and somewhat disappointing that common accommodations such as preferential seating during instruction have essentially no recent, high-quality research examining their effects, and even accommodations such as taking tests in a separate location have not yielded many studies.

17.3.4 Recommendations for Individual Accommodation Decisions

Beyond understanding the results of the extant research on accommodations for ADHD, diagnosticians, and accommodation decision-makers can use other strategies for making recommendations and decisions in individual cases. First, a student's functional skills must be assessed, and this is best done with measures of performance (diagnostic tests, records of real-world performance, or careful reports of performance from trustworthy sources such as teachers). Deficits in functional skills are a minimum requirement for accommodations to be considered, and knowing that a student has ADHD tells us very little about their functional skills. Even the severity of ADHD symptoms is actually not very strongly related to functional impairment (Lewandowski et al., 2016). If diagnostic tests are being used to determine functional skill levels, the tests that are most similar to real-world academic tasks should be administered and interpreted (Lovett & Bizub, 2019).

Second, relevant accommodations should—consistent with the life-course model—be considered when high-quality evidence-based interventions have failed, are not available, or are unlikely to succeed quickly enough. When functional skill deficits can be remediated through intervention, this is always preferable to changing the standards for what students must do. Even medication should be considered if the student's family and prescribing professional deem it appropriate. The situation of evidence-based psychosocial accommodations not being available may be a common one in many schools, and so medication interventions may happen alone.

Third, when accommodations are required, they should be narrowly tailored to the evidence of functional skill deficits identified earlier. For instance, a student with ADHD who has low reading fluency may require additional time to take reading-based tests, at least when the tests are not designed to measure speed, fluency, or automaticity of academic skills. Similarly, a student with more significant reading problems—or simply severe difficulty sustaining attention and engagement to a test—may benefit from a test reader. The adjustments should be as minimal as possible to avoid unfair advantages; for instance, if 25% additional testing time is sufficient to allow a student to access the test, there is no need to provide 50 or 100% additional time.

Finally, the use and effects of accommodations should be monitored in each individual case. Is the student actually using the accommodation? (If the accommodation is mediated by technology, does the student know *how* to use the accommodation properly?) Is the accommodation allowing the student to access instruction or assessments better? Speaking to teachers and students about this is enormously helpful, and at times it is appropriate to actually graph data from before and after accommodations are implemented.

17.4 Conclusions

A variety of school-based interventions and accommodations for ADHD are available, and some have shown efficacy and appropriateness. Although more research on these topics is always helpful, and it is particularly needed with regard to certain common accommodations, the primary challenge in practice may have shifted from "finding out what to do" to "doing what we have found to work." That is, the challenge has moved from discovery to implementation. Much scholarship in school psychology has discussed this type of challenge (see e.g., Forman et al., 2013; Walker, 2004; Sanetti & Collier-Meek, 2019), and a specialty field—*implementation science*—aims to address it directly. We know that inadequate training and resources are common causes of schools' lack of use of evidence-based practices, as are disagreements between professionals and perceived difficulty of implementation. Related but distinct issues lead to continued use of ineffective, inappropriate practices, and so more recently, *de-implementation science* has emerged as a term for scholarship on how to remove such practices (cf. Shaw, 2021). De-implementation may be the primary challenge with regard to overuse of accommodations (Lovett & Harrison, 2021). For both implementation and de-implementation challenges, effective school-based consultation skills are crucial, and a complete discussion of those skills is beyond the scope of this chapter. However, the first step is consultants learning what practices are in fact evidence-based, and it is our hope that the present literature review helps with that initial step.

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18 Assessment of Attention-Deficit/Hyperactivity Disorder in Children and Adolescents

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18.1 Introduction

All individuals experience moments of inattentiveness, hyperactivity, and impulsivity from time to time; however, the frequency and severity of these symptoms can be maladaptive and impairing for an individual. Assessment of attention-deficit/hyperactivity disorder (ADHD) involves consideration of the frequency and severity of symptoms as well as impairment in daily functioning. ADHD is a neurodevelopmental disorder characterized by experiencing abnormal symptoms of inattention (i.e., failing to complete tasks and difficulty following instructions) or hyperactivity-impulsivity (i.e., excessive talking and difficulty remaining seated when expected to) before age 12 for at least six months across two settings while causing significant impairment to one's daily life (American Psychiatric Association [APA], 2022).

18.2 ADHD Symptom Presentation

As previously mentioned, ADHD is characterized by atypical experiences of inattention and/or hyperactivity-impulsivity. Specifically, individuals diagnosed with ADHD experience six or more inattentive and/or hyperactive-impulsive symptoms for at least six months across two settings while causing significant functional impairment (APA, 2022). Of children diagnosed with ADHD, multiple studies have found a decrease in the frequency and severity of hyperactive-impulsive symptoms across the lifespan (Achenbach et al., 1995; Hart et al., 1995). Thus, the D*iagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-5*; APA, 2013) replaced the three subtypes of ADHD in previous editions of the *DSM* with the combined presentation, the predominantly inattentive presentation, and the predominantly hyperactive-impulsive presentation (Pinzone et al., 2019; Willcutt et al., 2012). Individuals who only experience six or more symptoms of inattention without experiencing symptoms of hyperactivity-impulsivity are diagnosed with the predominantly inattentive presentation while individuals who only experience six or more symptoms of hyperactivity-impulsivity without experiencing symptoms of inattention are diagnosed with the predominantly hyperactive-impulsive presentation. Individuals experiencing six or more inattentive and hyperactive-impulsive symptoms are diagnosed with the combined presentation.

18.3 Occurrence and Sociodemographic Variables

ADHD is the most common childhood neurodevelopmental disorder affecting 5–8% of

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children (APA, 2022; Faraone et al., 2003; Pinzone et al., 2019). These symptoms reportedly persist into adolescence with 75% of individuals who were diagnosed with ADHD as children continuing to experience symptoms as adolescents (Barkley et al., 1990b; Mick et al., 2004). Results from Mowlem et al. (2019) suggest that the predominantly inattentive presentation is the most common ADHD diagnosis for children followed by the combined presentation and the predominantly hyperactive-impulsive presentation, respectively.

ADHD is more frequently diagnosed in boys at an estimated rate of two to one or higher (APA, 2022; Nigg & Barkley, 2014; Polanczyk et al., 2007). This is likely due to higher evaluation and treatment referrals for boys based on higher levels of activity, disruption, and, in some cases, aggression (Nigg & Barkley, 2014). It is reported that girls are more likely to experience inattention symptoms and are more frequently diagnosed with the predominantly inattentive presentation of ADHD (APA, 2022; Nigg & Barkley, 2014). However, studies have found similarities between patterns of executive functioning and cognitive control impairments in girls and boys diagnosed with ADHD (Hinshaw et al., 2002; Rucklidge & Tannock, 2001) as well as risk for negative outcomes involving academic performance and social functioning (Hinshaw et al., 2012; Owens et al., 2009). These findings suggest that more research is necessary to understand the reason for the gender differences in diagnosing and treating ADHD.

Furthermore, ADHD is present at all socioeconomic levels; however, studies examining differences in diagnosis rates at each level are inconsistent in describing the relationships between ADHD and socioeconomic status (SES; Nigg & Barkley, 2014). It is reported that children from lower-SES backgrounds are more likely to be diagnosed with ADHD (Szatmari, 1992; Trites, 1979) with some exceptions. For instance, Nigg and Barkley (2014) suggest that there was less variability in ADHD prevalence across socioeconomic levels when more individuals (i.e., parents, teachers, and doctors) concurred with the diagnosis (Lambert et al., 1978). Additionally, the relationship between ADHD and lower-SES backgrounds was no longer found when controlling for comorbid diagnoses (i.e., oppositional defiant disorder (ODD) and conduct disorder (CD); Nigg & Barkley, 2014; Szatmari et al., 1989). Thus, further research is necessary to determine the relationship between SES and ADHD prevalence.

18.4 Etiology

18.4.1 Brain Function and Structure

Researchers have identified several possible differences in the brains of those diagnosed with ADHD compared to those without. The most consistent finding is an overall reduction in total brain size with specific changes in the caudate nucleus, prefrontal cortex white matter, corpus callosum, and cerebellar vermis (Tripp & Wickens, 2009). For example, studies using neuroimaging have indicated that anterior brain regions (e.g., right frontal white matter) and specific subregions in brain areas involved in coordinating activities of multiple brain regions are smaller in individuals with ADHD, whereas posterior regions (e.g., occipital lobes) may be larger (Swanson et al., 2007; Valera et al., 2007).

Additionally, neuroimaging has shown abnormalities in the frontostriatal circuit connectivity and function, reduced activation of the prefrontal cortex and striatal regions (Dickstein et al., 2006; Faraone et al., 2015). As this circuit is responsible for executive processes (e.g., decision-making, impulse control, time management, focus, and organization skills), the reduced activation of these structures may result in impaired executive functioning (Barkley et al., 2008; Zamorano et al., 2017). Further, problems in executive functioning often manifest as symptoms of inattention, hyperactivity, and impulsivity due to poor emotional and behavioral inhibition and interference control (Vaidya & Stollstorff, 2015; Zamorano et al., 2017).

Other studies have suggested that people with ADHD may have an imbalance in the level of neurotransmitters in the brain, or that these chemicals may not work properly. Children with ADHD tend to respond well to stimulants, which work by increasing levels of dopamine and norepinephrine in the brain, as well as noradrenergic antagonists (Arnsten, 2009; Connor, 2006). Researchers have debated whether both neurotransmitters play a role in ADHD, particularly norepinephrine (Halperin et al., 1997; Rapoport et al., 1978). However, it is clear that stimulants increase dopamine levels at the synaptic level related to reinforcement sensitivity, resulting in symptom reduction (Nigg & Barkley, 2014; Swanson et al., 2007).

18.4.2 Genetics

Researchers have shown that ADHD runs in families, with a heritability of approximately 74% (APA, 2022). Family, adoption, and twin studies suggest that unspecified genetic factors may be the predominant cause of the disorder (Swanson et al., 2007). Molecular genetic methods have been used to identify a number of common gene markers associated with ADHD, predominantly the association with dopamine genes (Langley et al., 2004; Nigg & Barkley, 2014). As of now, there is no single gene identified as an etiological mechanism for ADHD.

18.4.3 Environmental Factors

Researchers suggest that environmental exposures to certain toxic substances (e.g., nicotine) and fetal adaptations (e.g., low birth weight) are associated with increased risk for ADHD (Linnet et al., 2005; Swanson et al., 2007). Prenatal maternal smoking has been associated with symptoms of ADHD in children based on family studies (Linnet et al., 2005); however, more recent literature indicates that the causal effects of nicotine exposure may be smaller than previously believed (Nigg & Barkley, 2014). While alcohol exposure in utero, neurotoxin exposure (e.g., lead), and infections (e.g., encephalitis) have been correlated with ADHD symptoms, it is unclear whether these correlates are causal (Nigg & Barkley, 2014; Swanson et al., 2007). Additionally, low birth weight (<2500 g) and premature birth (<37 weeks gestation) are risk factors for ADHD. However, as birth weight is determined by multiple factors (e.g., maternal health and nutrition, maternal weight, and low socioeconomic status), it is difficult to identify specific biological mechanisms (Nigg & Barkley, 2014).

18.4.4 Gene X Environment Interaction

Meta-analysis findings suggest interactions of psychological distress measures and genotype, particularly for DAT1 and 5-HTTLPR, may reliably predict ADHD (Nigg & Barkley, 2014). Though the results were reliable and consistent, the studies consisted of small sample sizes, warranting further investigation.

18.5 Comorbidities and Prevalence

Of children diagnosed with ADHD in clinical samples, 80–87% have at least one co-occurring disorder with the most common being externalizing disorders (APA, 2022; Kadesjo & Gillberg, 2001). Specifically, ODD is the most common comorbid disorder affecting 54–57% of children with ADHD by age seven (Nigg & Barkley, 2014). Additionally, ODD serves as a precursor to or occurs with CD which affects up to 50% of children and adolescents with ADHD (Barkley, 2006; Barkley et al., 1990b; Biederman et al., 1992; Lahey et al., 2000). Childhood ADHD is highly correlated with developing a substance use disorder later in life, and this correlation is strengthened with the presence of prior or co-occurring CD (Burke et al., 2001; Charach et al., 2011; Lee et al., 2011). ADHD is also found to be comorbid with autism spectrum disorder (ASD), tic disorders, anxiety disorders, and mood disorders; however, the prevalence of these conditions is variable in children with ADHD (APA, 2022; Nigg & Barkley, 2014).

18.5.1 Evidence-Based Assessments

As there are no specific biological markers for ADHD, psychological assessment is necessary for diagnosis. Psychological assessment is primarily conducted by trained clinicians to determine whether a child exhibits developmentally inappropriate levels of inattention and/or hyperactivity and impulsivity as outlined by the *DSM-5* diagnostic criteria. This process is valuable in identifying children and adolescents whose symptoms impede their daily functioning to improve current and future outcomes across various domains (Barkley et al., 2008; Kuriyan et al., 2013). Psychological assessment involves the clinician gathering information about the child via multiple methods across various sources including parents, the child, and teachers.

Many methods used by clinicians are evidence-based meaning that their reliability and validity properties are previously established using statistical analyses. By using assessment methods with previously established psychometric properties, the likelihood of making an accurate diagnosis increases (Mash & Hunsley, 2005). Common methods used in the psychological assessment of ADHD involve unstructured interviews, structured or semi-structured diagnostic interviews, questionnaires, and, in some cases, executive functioning measures such as neuropsychological tests, questionnaires, and continuous performance tests. The clinical application of these methods as well as the psychometric properties of specific interviews, questionnaires, and tests will be reviewed in this chapter.

18.5.2 Unstructured Interviews

The clinical interview is the most commonly used technique to assess or evaluate clients for any psychological condition. The ultimate goal of the clinical interview is to determine an accurate diagnosis by defining symptom patterns, and it is also a beneficial method for building rapport with the client (Herbert et al., 2010; Mueller & Segal, 2014). Unstructured interviews are free-flowing assessments that allow the clinician to gather information about the client's experience in an almost conversational format (Mueller & Segal, 2014). Its informal nature allows the client to ease into the assessment process and establish rapport with the clinician; thus, it is typically recommended that the assessment starts with an unstructured interview. There are many important areas that the clinician should inquire about in the unstructured interview including the presenting problem or reason for referral, the client's developmental background, social and academic history, daily routine, and physical health/medical history. This information, while not inherently indicative of the presence of a psychological disorder, provides contextual information about the client and assists in determining which areas the clinician should examine in greater detail.

Unstructured interviews are not standardized meaning that the clinician must determine what information is pertinent to the assessment and what questions will be asked. For this reason, the information and questions selected are influenced by the clinician's background including their training experiences, theoretical model of practice, knowledge of assessment and psychopathology, and interpersonal style (Mueller & Segal, 2014). This is important to note as it may introduce clinician bias into the assessment process. For example, the questions selected by the clinician may be limited and not fully capture enough information to support case conceptualization or diagnosis (Mueller & Segal, 2014). Consequently, it is recommended that clinical assessment involve multiple, evidence-based methods in order to increase diagnostic accuracy (Frick et al., 2010).

18.5.3 Diagnostic Interviews

An example of additional evidence-based methods that aid in improving clinical accuracy is the inclusion of diagnostic interviews. Diagnostic interviews are standardized meaning that they are composed of a list of specific questions designed to evaluate whether the individual meets diagnostic criteria for various disorders based on *DSM-5* criteria (Mueller & Segal, 2014). They also provide systemized methods for rating the client's responses. Due to their uniform design and application, diagnostic interviews are less prone to clinician bias and aid in clinical judgment by assessing for multiple diagnoses and distinguishing between symptom criteria for differential diagnoses (Mueller & Segal, 2014). These interviews may be structured (e.g., the clinician administers the interview as specified and does not deviate from the format) or semi-structured. Semi-structured interviews involve a standardized set of questions but allow the clinician leeway in asking follow-up questions to gather additional context or details (Mueller & Segal, 2014).

18.5.4 ADHD Child Evaluation

The ADHD Child Evaluation (ACE; Young, 2015) is a semi-structured diagnostic interview used to assess the presence and impairment of inattention, hyperactivity, and impulsivity symptoms in children ages five to 16. It is primarily used with parents or adult informants who know the child well, but it can be administered directly to older children. The interview begins with the clinician gathering background information including a medical and educational history, peer and family relationship history, and the presence of early risk factors (i.e., low birth weight). Following this, the interviewer asks the informant questions regarding the presence of inattention, hyperactivity, and impulsivity symptoms. Specifically, informants are asked to determine whether the symptom is present at home and/or school given a brief description of how this symptom commonly manifests in daily life. If the informant reports that a symptom is present, they are asked to provide an example of how this symptom manifests in the child's daily life as well as its onset, duration, pervasiveness, and impairment. The interview also includes sections for the interviewer to list observations of the child's behavior during interactions with the child and to consider the presence of common coexisting conditions of ADHD or differential diagnoses.

Given the informant's report, the interviewer determines whether symptoms of inattention and/or hyperactivity are present. For the interviewer to consider an ADHD symptom clinically significant, it must be present at home and school, interfere with the child's daily functioning for the past six months, and is not better explained by another condition. The endorsement of at least six inattention symptoms suggests the presence of the predominantly inattentive classification, while the endorsement of at least six inattention symptoms suggests the presence of the predominantly hyperactive/impulsive classification. The combined classification is met if at least six inattention symptoms and six hyperactivity/impulsivity symptoms are endorsed.

The ACE is offered online and is free to use. There are also online resources provided for clinicians to help guide scoring according to *DSM-5* and International Classification of Diseases (tenth edition; ICD-10) criteria (Weiss, 2022). There is limited information regarding the psychometric properties of this interview, and further research should be conducted to determine the reliability and validity properties of the ACE.

18.5.5 Kiddie-Schedule for Affective Disorders and Schizophrenia for School-Aged Children-Present and Lifetime Version DSM-5 (K-SADS-PL-5)

The Kiddie-Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime version (K-SADS-PL-5; Kaufman et al. 1997) is a semi-structured diagnostic interview used to measure current and past symptoms of mood, anxiety, psychotic, and disruptive behavior disorders in children and adolescents ages six to 18. The interview consists of screening interviews with key symptoms for 35 disorders plus diagnostic supplements and provides diagnoses according to DSM-5 criteria. It is available in various translations, including English, Chinese, Turkish, and Japanese.

The K-SAD-PL-5 is initially completed with each informant separately. Before beginning the KSADS interview, the caregiver(s) and child must independently complete a self-report to assess the severity of *DSM-5* symptoms over the past two weeks. The caregiver(s) and child then complete an unstructured interview in which the caregiver(s) provide information about health, presenting complaint(s), and prior psychiatric treatment data, and both the caregiver(s) and child are asked about the child's school functioning, hobbies, and peer and family relations. Next, the clinician administers a diagnostic screen interview to survey the core symptoms of the different diagnoses assessed by the K-SADS-PL-5. If there is an indication of current or past psychopathology, the appropriate diagnostic supplements are administered at the end of the screen interview. The majority of the items in the K-SADS-PL-5 are scored on a three-point rating scale with a score of three representing clinically significant impairment. To determine whether the youth meets the criteria for a disorder, the clinician must review summary ratings of all sources of information (Kaufman et al., 2016).

The earlier version of the K-SADS-PL exhibits excellent inter-rater reliability, good to excellent test–retest reliability, and well-supported concurrent validity (Kaufman et al., 1997); however, evidence regarding the psychometric properties of the English version of the K-SADS-PL-5 is limited. Similarly, the Turkish version of the K-SADS-PL-5 exhibited good to excellent inter-rater reliability across domains, while the Spanish and Icelandic versions were found to have fair to excellent inter-rater reliability (Marques et al., 2022; Ünal et al., 2019). Test–retest reliability ranged from good to excellent for all disorders, and agreement between clinical and interview diagnoses was good to excellent in inpatient and outpatient youth (Marques et al., 2022). The K-SADS-PL-5 is available in multiple translations, including Chinese, Japanese, and Korean.

18.5.6 The Anxiety Disorders Interview Schedule for DSM-IV Child and Parent Version

The Anxiety Disorders Interview Schedule for DSM-IV Child and Parent Version (ADIS-IV: C/P; Silverman & Albano, 1996) is a semi-structured diagnostic interview used to assess for the presence, severity, and level of interference of various emotional and behavioral concerns in youth ages six to 18 based on *DSM-IV* diagnostic criteria. It is primarily used for the assessment of internalizing disorders (i.e., specific phobia, generalized anxiety disorder, major depressive disorder, etc.); however, it also includes modules for externalizing disorders (i.e., ADHD and ODD) as well as screening measures for other behavior concerns including eating disorders, enuresis, and schizophrenia. The ADIS-IV: C/P can be administered in whole or in portions to probe for specific disorders or problems.

Administration of the ADIS-IV: C/P involves the clinician asking the child or caregiver to endorse the severity or impairment of the youth's symptoms using a nine-point scale ranging from zero (not present) to eight (very severe/ impairing). Symptoms endorsed as a four or higher indicate clinically significant severity or impairment. To determine whether the youth client meets the diagnostic criteria for a disorder, the clinician must consider the symptom information provided by the caregiver and child interviews together (Silverman & Albano, 1996).

Studies examining the psychometric properties of the ADIS-IV: C/P found it to have strong test–retest and inter-rater reliability (Grills & Ollendick, 2003; Silverman & Nelles 1988; Silverman et al. 2001) as well as adequate convergent validity and concurrent validity (Langer et al., 2010; Wood et al. 2002) overall in typically developing youth. With regard to ADHD assessment, the ADIS-IV: C/P demonstrated good test–retest and inter-rater reliability for the ADHD and ODD portions of the interview. The ADIS-IV: C/P also includes an addendum for ASD which exhibited good to excellent inter-rater reliability across modules (Kerns et al., 2014; Ung et al., 2014). The ADIS-IV: C/P is offered in multiple translations including Spanish, French, and Portuguese (Grisham et al., 2004).

18.5.7 National Institute of Mental Health Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV)

The National Institute of Mental Health Diagnostic Interview Schedule for Children Version IV (DISC-IV; Shaffer et al., 2000) is a highly structured diagnostic interview. It consists of approximately 3000 questions to assess for over 30 psychiatric diagnoses including ADHD based on *DSM-IV* diagnostic criteria. Specifically, six modules assess for the presence of anxiety disorders, mood disorders, disruptive behaviors, substance use disorders, schizophrenia, and miscellaneous disorders. Additionally, there is an optional whole life module that assesses whether diagnoses that an individual does not currently meet criteria for were present after age five and prior to the current year. The DISC-IV offers a version for parent/caregiver informants of youth ages six to 17 (DISC-P) and another version for youth respondents ages nine to 17 (DISC-Y). Both versions are interviewer-administered and offered in computer or paper format. Additionally, there is a computerized audio version offered for self-administration (Shaffer et al., 2000). The DISC-IV is offered in English, Spanish, and Korean (Cho et al., 2007; Shaffer et al., 2000).

Administration of the DISC-IV involves the clinician asking the informant short and direct questions about the youth's behavior verbatim. The majority of questions require the informant to provide a "yes" or "no" response. These include broad "stem" questions that represent the general diagnostic criteria for specific disorders as well as "contingent" questions that determine the frequency, duration, and intensity of symptoms endorsed. For disorders where a significant number of symptoms are endorsed (e.g., approximately half), there are also questions regarding the youth's age of onset, functional impairment, and treatment. Scoring can be completed via hand or computer; however, computer-scoring is preferred due to the erroneous nature of hand-scoring.

Evidence regarding the psychometric properties of the DISC-IV is variable. The English and Korean versions of the DISC-IV exhibit adequate test-retest reliability across domains (Cho et al., 2007; Shaffer et al., 2000) while the Spanish version was found to have fair to moderate test-retest reliability (Bravo et al., 2001). Studies have also found mixed evidence regarding inter-rater reliability of the DISC-IV. Inter-rater reliability ranged from moderate to substantial for anxiety disorders, mood disorders, and disruptive behaviors (Shaffer et al., 2000) and was adequate between clinical diagnosis and DISC-IV in a sample of adolescent inpatients (Roberts et al., 2005). In contrast, inter-rater reliability across diagnoses was reportedly fair when half of the participants identified as a racial/ethnic minority (Lewczyk et al., 2003). Studies examining the validity of the DISC-IV are limited and require evaluation.

18.5.8 Young Diagnostic Interview for ADHD-5

The Diagnostic Interview for ADHD (DIVA-5; Kooij et al., 2019) is a semi-structured interview to assess ADHD symptoms in adult populations based on *DSM-5* criteria. It measures the presence and frequency of inattention and hyperactivity/impulsivity symptoms in adulthood and childhood as well as the functional impairment caused by these symptoms (El Archi et al., 2023). It has been adapted to use with children and adolescents (Young DIVA-5; Kooij et al., 2019) by providing a list of common symptoms and impairment examples relevant to the youth population. Studies examining the psychometric properties of previous versions of the DIVA-5 (DIVA 2.0) found support for its interrater reliability as well as its concurrent and divergent validity (Pettersson et al., 2018; Ramos-Quiroga et al., 2019). Studies have examined the utility of Korean and Farsi translations of the DIVA-5 and found that it demonstrates high sensitivity and specificity in detecting individuals with and without ADHD (Hong et al., 2020; Zamani et al., 2021). However, studies examining the psychometric properties of the original DIVA-5 and Young DIVA-5 are limited. This is important to note as this measure is widely used in ADHD assessment for adults and children. Further research is necessary to determine the clinical utility of the Young DIVA-5 in ADHD assessment.

18.5.9 Questionnaires

Another supplemental measure frequently used in evidence-based assessment is questionnaires. Questionnaires aid in improving the clinical accuracy of diagnostic assessment by allowing for multiple informants to report on the clients' behavior. In youth ADHD assessment, questionnaire informants typically involve parents and teachers; however, older children may complete self-report measures to describe their own thoughts, feelings, and behaviors. The inclusion of questionnaires provides the clinician with information regarding the severity and frequency of the client's behaviors. By collecting this information from multiple reporters, the clinician is better able to understand whether the client's behavior is more severe than expected for their age.

18.5.10 The Conners' Rating Scales-3rd Edition

The Conners' Rating Scales-3rd Edition (Conners' 3; Conners, 2008) are widely used in assessing ADHD in children and adolescents between the ages of six and 18 as well as comorbid disorders using diagnostic criteria specified by the *DSM-5*. The Conners' 3 forms consist of six content domains and four *DSM-5* symptom domains related to ADHD, ODD, and CD. Additionally, the Conners' 3 offers versions for multiple informants including parent and teacher measures, the Conners' 3 Parent Rating Scale (PRS) and Conners' 3 Teacher Rating Scale (TRS), respectively, as well as the Conners' 3 Self Report Scale for the youth respondent. These scales are offered in a short version (27 items) as well as a long version (80 items). Informants rate the frequency and severity of the client's behavior on a four-point scale (0 = not true at all, 1 = just a little true, 2 = pretty much true, 3 = very much true). The scores of each item are then summed to create a raw score for their respective scales. The raw scores for each scale are then converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores indicating higher clinical severity. Specifically, T-scores between 60 and 65 are considered to be subclinical elevations, and T-scores greater than 65 are considered to be clinical elevations.

Conners' 3 measures demonstrate good to excellent internal consistency (Cronbach's $\alpha = 0.77$ to 0.97; Conners, 2008). Additionally, the Conners' 3 is reported to have acceptable test–retest reliability at 2 and 4 weeks ($r = 0.71$ to 0.98; Conners, 2008) and inter-rater reliability ($r = 0.52$ to 0.94; Conners, 2008). Furthermore, Conners (2008) also found that Conners' 3 exhibited acceptable convergent and discriminant validity as a result of its ability to differentiate between children in the general population as well as children with ADHD-related disorders (i.e., learning disorders and disruptive behavior disorders).

18.5.11 National Institute for Children's Health Quality (NICHQ) Vanderbilt Assessment Scale

The NICHQ Vanderbilt Assessment Scale (Wolraich et al., 2003) is another measure assessing common disorders among youth between the ages of six and 12 using diagnostic criteria specified by the DSM-IV. Specifically, the Vanderbilt includes items assessing six symptom domains (i.e., ADHD predominantly inattentive presentation, the ADHD predominantly hyperactive-impulsive presentation, ADHD combined presentation, ODD, CD, and anxiety and depression) as well as performance items used to determine whether the symptoms interfere with the child's daily functioning. Both parent and teacher report forms (TRF) are used to assess the frequency and severity of the child's behavior.

Informants rate the frequency of the symptom items based on the child's behavior in the last six months using a four-point scale (0 = never, 1 = occasionally, 2 = often, 3 = very often). Performance items are rated based on the severity of academic and social behaviors using a five-point scale (1 = excellent functioning, 2 = above average functioning, 3 = average functioning, 4 = somewhat problematic functioning, 5 = problematic functioning). Severity item scores rated as two or three represent symptom presence while performance item scores rated as four or five represent impairment presence. Higher severity item scores indicate a higher frequency of symptoms. Only one performance item must be endorsed to indicate that the individual experiences functional impairment. The Vanderbilt ADHD Diagnostic Parent Rating Scale (VADPRS) and Teacher Rating Scale (VADTRS) provide recommended diagnostic cutoffs set by the NICHQ and American Academy of Pediatrics to aid in identifying the presence of these disorders (Wolraich et al., 2003).

Wolraich et al. (2003, 2004) found that the VADPRS exhibited adequate internal consistency, factor structure, and concurrent validity. Additionally, the comorbidity symptom scales were also found to have acceptable reliability and factor structure (Wolraich et al., 2003). Although the results of Wolraich (2003) suggested that the comorbidity symptom scales exhibited adequate concurrent validity, Becker et al. (2012) found that the total sum of the severity item score provides greater clinical utility for the identification or "ruling out" of the comorbidity symptom scales than the recommended diagnostic cutoffs with the exception of the ODD symptom scale. This is an important consideration for clinicians in distinguishing between differential diagnoses in ADHD assessment.

18.5.12 ADHD Rating Scale-IV

The ADHD Rating Scale-IV (ADHD-RS; DuPaul et al., 1998) is used to assess the frequency of inattention and hyperactivity/impulsivity symptoms based on the *DSM-IV* diagnostic criteria. Parent, teacher, and clinician report forms are offered to aid in the evaluation of ADHD symptoms in children ages sive to 18. Specifically, the ADHD-RS is an 18-item measure with nine items assessing inattention symptoms and nine items assessing hyperactivity/impulsivity symptoms. Informants rate the frequency of the symptom items based on the child's behavior in the last six months using a four-point scale (0 = never/rarely, 1 = sometimes, 2 = often, 3 = very often). The scores of each item are then summed to create a Total Scale score, the odd-numbered items are summed to create a total Inattention subscale score, and the even-numbered items are summed to create a total hyperactivity/impulsivity subscale score. The raw scores for each scale are then converted to percentile scores based on the child's gender and age. Higher percentile scores indicate a higher frequency of inattention and/or hyperactivity/impulsivity symptoms. Zhang et al. (2005) found that the ADHD-RS demonstrated acceptable test–retest reliability, internal consistency, factor structure, convergent validity, divergent validity, discriminant validity, and responsiveness. However, it is important to note that the items of the ADHD-RS are based on *DSM-IV* criteria and have not been updated to reflect the diagnostic criteria changes of ADHD in the *DSM-V*. Clinicians should consider this when using the ADHD-RS in current ADHD assessment.

18.5.13 The Child Behavior Checklist 6–18 (CBCL 6–18) and Related Questionnaires

The Child Behavior Checklist 6–18 (CBCL 6–18; Achenbach & Rescorla, 2001) is a parent-report measure used to assess common behavioral and emotional problems among youth between the ages of 6 and 18. The Achenbach System of Empirically Based Assessment developed parallel instruments to allow for multiple informants including the Caregiver-TRF, a caregiver and preschool teacher-report measure to assess the behaviors of young children ages one and a half to five, the TRF, a teacher-report measure to assess the behaviors of youth ages six to 18, and the Youth Report form (YRF), a self-report measure for informants ages 11–18. The CBCL 6–18, TRF, and YRF are composed of 132 parallel items including 20 adaptive functioning items and 120 problem behavior items while the Caregiver-TRF is composed of 91 problem behavior items.

Problem behavior items are used to assess the child's internalizing, externalizing, and total problems, as well as problems related to common childhood *DSM-IV* disorders. Informants are asked to rate the frequency of the youth client's problem behaviors in the last six months using a three-point scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true, very often true). All four forms also offer open-ended questions that allow respondents to list the youth client's strengths, concerns, as well as physical problems. These four questionnaires are self-administered via pencil-and-paper or computer, or they can be offered verbally for individuals with inadequate literacy (Achenbach & Rescorla, 2001). Scoring is completed using a computer software system that compares the client's score to age and gender norms. The raw scores for each scale are converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores of problem behaviors indicating a higher likelihood of clinical severity.

The psychometric properties of the CBCL 6–18 and related instruments are reportedly strong. When examining the scale's utility for nonclinical, clinical, and diverse samples, Achenbach and Rescorla (2001) found that these measures exhibit high test–retest reliability, inter-rater reliability, and internal consistency with the exception of the TRF which exhibited low to moderate inter-rater reliability. Additionally, the CBCL 6–18, TRF, and YSF were found to have good construct validity as evidenced by individuals in the clinical sample scoring higher than those in the nonclinical sample (Achenbach & Rescorla, 2001; Naar-King et al., 2003). Furthermore, the scales exhibit moderate to high correlations between the CBCL 6–18, TRF, and YSF compared to similar youth behavior scales, suggesting good criterion validity (Achenbach & Rescorla, 2001; Naar-King et al., 2003). However, it is important to note that the norms used to develop these measures did not assess children with medical difficulties; therefore, scores for individuals in this population may be more sensitive and elevate easier than peers of the same age (Naar-King et al., 2003).

18.5.14 Behavior Assessment Scale for Children (BASC)

The Behavior Assessment Scale for Children, Third Edition (BASC-3; Reynolds & Kamphaus, 2015) is a multi-method system used to assess various internalizing, externalizing, and adaptive problems among youth between the ages of two and 21. The BASC-3 involves multiple assessment tools including parent and teacher questionnaires, the PRS and the TRS, respectively, as well as the BASC-Self-Report of Personality (SRP) for the youth respondent. The PRS and TRS have three levels based on the child's age: preschool (ages two to five), child (ages six to 11), and adolescent (ages 12–21) which vary in the number of items. The questionnaire can be administered via paper form or electronically through a web-based administration and scoring system (Q-global).

Informants using the PRF and TRF rate the frequency and severity of the client's behavior on a four-point scale (0 = never, 1 = sometimes, 2 = often, 3 = always). Youth respondents use the same four-point scale to answer items as well as an additional true or false response format (True = 0, False = 1). The scores of each item are then summed to create a raw score for their respective scales. This can be done by hand or by using Q-global. The raw scores for each scale are then converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores indicating higher clinical severity. Specifically, T-scores between 60 and 69 are considered to be subclinical elevations, and T-scores greater than 70 are considered to be clinical elevations.

In assessing ADHD symptoms using the BASC-3 PRS, TRS, and SRP, the attention problems and hyperactivity clinical scales are used to determine whether the child's inattention and hyperactivity symptoms are significantly greater than their same-age peers. Furthermore, the Executive Functioning Index includes a scale measuring Attentional Control that can also help to determine if the child exhibits significantly greater difficulties with attention compared to their peers.

The BASC-3 PRF, TRF, and SRP exhibit good internal consistency and test–retest reliability; however, the inter-rater reliability across the PRF (r = 0.67 to 0.82; Reynolds & Kamphaus, 2015) and TRF (r = 0.62 to 0.77; Reynolds & Kamphaus, 2015) was variable across the preschool, child, and adolescent levels. Several studies have examined the validity of previous versions of the BASC and found it to have appropriate convergent and discriminant validity (Reynolds & Kamphaus, 2004). However, there are limited studies evaluating the validity properties of the BASC-3 PRF, TRF, and SRP.

18.6 Neuropsychological Measures

As previously mentioned, ADHD is a neurodevelopmental disorder characterized by abnormal symptoms of inattention, hyperactivity, and impulsivity. While there are no specific biological markers to confirm the presence of ADHD, neuropsychologists have frequently examined the relationship between executive functioning and ADHD symptomatology. Executive functioning is characterized by the accumulation of processes involved in goal-related behaviors including but not limited to planning and organizing information, initiating and monitoring one's behavior, and problem-solving/shifting behavior (Araujo Jiménez et al., 2015; Gioia et al., 2001; Roth et al., 2013). This is important to note as children and adolescents diagnosed with ADHD exhibit difficulties in related areas such as inhibition, planning, organization, updating, shifting, flexibility, working memory, and emotional control (Araujo Jiménez et al., 2015; Barkley, 2001; Brocki et al., 2010; Holmes et al., 2010, Re et al., 2010; Willcutt et al., 2005). Thus, the inclusion of neuropsychological tests in ADHD assessment can be useful in determining whether the child's difficulty with attention is best attributed to ADHD symptomatology or neurocognitive difficulties.

While executive dysfunction and ADHD symptomatology are related, executive dysfunction is not classified as an etiological mechanism of ADHD (APA, 2022). Critics of the DSM-5 ADHD diagnostic classification argue that the current diagnostic model for ADHD overemphasizes behavioral symptoms of ADHD and minimizes the role of potential biological markers, cognition, and brain function (Kinderman et al., 2013; Malla et al., 2015; Timimi, 2014). Thus, measures evaluating the behavioral symptoms of ADHD exhibit greater diagnostic utility than measures of executive functioning alone (Barkley & Fischer, 2011; Barkley & Murphy, 2011; Biederman et al., 2008). Despite these findings, studies have found that the inclusion of neuropsychological tests and measures including continuous performance tests in ADHD assessment batteries are more accurate in predicting ADHD diagnoses than those without (Jarrett et al., 2018; Nikolas et al., 2019; Tallberg et al., 2019). Specifically, neuropsychological tests evaluating one's working memory, shifting, and interference inhibition were found to distinguish between individuals with and without ADHD (Frazier et al., 2004; Hervey et al., 2004; Homack & Riccio, 2004; Martinussen et al., 2005; Willcutt et al., 2005). We will review various neuropsychological tests, executive functioning questionnaires, and continuous performance tests that are included in ADHD assessment.

18.6.1 Neuropsychological Tests

The Digit Span test is a subtest of the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V; Wechsler, 2014) used to assess working memory in children. The examiner states a series of number sequences for the client to repeat as stated (Digits Forward), in reverse (Digits Backward), and in chronological order (Digit Sequencing). Following administration, the scores for each scale are summed to create a total Digit Span subtest raw score which is converted into a T-score (M = 10, SD = 3) based on an age normative sample. Higher scores indicate better working memory ability in children. The Digit Span test is a useful tool in determining whether impairment is working memory ability is present, and studies have found that working memory ability tests can help distinguish between individuals with and without ADHD (Martinussen et al., 2005; Willcutt et al., 2005). Working memory deficits are associated with the presence of hyperactivity and inattention symptoms (Kofler et al., 2010; Rapport et al., 2009; Wells et al., 2018). Therefore, the Digit Span subtest can be utilized as a supplemental measure in ADHD assessment.

The Wisconsin Card Sorting Test (WCST; Grant & Berg, 1993; Heaton et al., 1993) is another common neuropsychological test used in ADHD assessment that measures an individual's set shifting ability (Frazier et al., 2004; Willcutt et al., 2005). In administering this test, four stimulus cards (one red triangle, two green stars, three yellow crosses, and four blue circles) are presented, and the client is asked to match each card from the response deck to one of the four stimulus cards. The sorting criteria are not told to the client and change with each card; thus, the client must adjust or shift their responses to follow the new criteria. Examples of criteria include sorting by color, form, or number. The client is given immediate feedback as to whether they correctly or incorrectly matched the card. Following administration, the test is scored to measure the client's percent correct, preservation errors, categories completed, failure to maintain set, and trials to first. Results of a meta-analysis by Romine et al. (2004) found that children with ADHD performed more poorly on the WCST than children without a clinical diagnosis; however, children with ADHD performed better than children with various other clinical diagnoses. Thus, the poor performance of the WCST reflects trouble with ADHD-related executive dysfunction but is not indicative of clinically significant ADHD symptoms on its own.

The Trail Making Test (Reitan & Wolfson, 1985) is a useful test for measuring various cognitive processes including shifting and interference inhibition in children. To complete the test, the client is instructed to connect circles containing numbers in chronological order in Part A. In Part B, the circles contain numbers and letters, and the client is instructed to connect the circles while alternating between chronological and alphabetical order (e.g., 1, A, 2, B, etc.). This part requires the client to hold their place in the alphabetical and numerical series and also recall which letter or number is next. The client is timed while completing this test, and greater time spent completing both parts suggests executive functioning deficits. Studies have found that individuals with ADHD perform worse than those without ADHD on the Trail Making Test (Frazier et al., 2004; Willcutt et al., 2005); therefore, it can be utilized as a supplemental measure in ADHD assessment.

18.6.2 Executive Functioning Questionnaires

18.6.2.1 Behavior Rating Inventory of Executive Function

The Behavior Rating Inventory of Executive Function (BRIEF) is a measure used to assess impairment in the many components of executive functioning among youth between the ages of five and 18 (Roth et al., 2013). The BRIEF offers versions for multiple informants including parent and teacher measures as well as a self-report measure for youth respondents ages 11–18. There is also a parent-report measure for preschool children. Informants rate the frequency of the client's behavior on a three-point scale (1 = never, 2 = sometimes, 3 = often). Scoring can be completed by hand using a computer software system to compare the client's score to age and gender norms. The raw scores for each scale are converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores indicating higher impairment in areas of executive functioning. Specifically, the BRIEF includes items assessing eight clinical domains relevant to executive functioning (i.e., Inhibit, Shift, Emotional Control, Initiate/Task Completion, Working Memory, Plan/Organize, Organization of Material, Monitor). These scales form two broader indexes (i.e., Behavioral Regulation and Metacognition) as well as an overall score (i.e., Global Executive Composite).

The BRIEF demonstrates high internal consistency (Cronbach's α = 0.80 to 0.98) and test-retest reliability (r = 0.82 to 0.88) across the different versions (Roth et al., 2013). However, the inter-rater reliability of the various BRIEF questionnaire forms is poor (r = 0.19 to 0.57; Roth et al., 2013). Roth et al. (2013) found that adolescent self-report ratings had higher correlations with parent ratings than teacher ratings. This is important to consider as demands in the school environment may differ from those at home. The BRIEF parent version also demonstrates moderate to high correlations with measures of ADHD including the Conners' 3 PRS, the ADHD-IV Rating Scale, as well as the CBCL and BASC Attention Problem Scales (Jarratt et al., 2005; Mahone & Hoffman, 2007; Mahone et al., 2002; McCandless & O'Laughlin, 2007; Roth et al., 2013). McCandless and O'Laughlin (2007) found the BRIEF parent ratings to have clinical utility in the assessment of ADHD in clinical samples. Specifically, the Metacognitive Index was found to accurately distinguish between individuals without ADHD symptoms and those with ADHD predominantly inattentive and combined presentations, and the Behavior Regulation scale was found to distinguish between children with ADHD combined presentation and children with ADHD predominantly inattentive presentation and children without ADHD symptoms (McCandless & O'Laughlin, 2007).

18.6.3 Barkley Deficits in Executive Functioning Scale-Children and Adolescents

The Barkley Deficits in Executive Functioning Scale-Children and Adolescents (BDEFS-CA; Barkley, 2012) is a measure created as an extension of the adult BDEFS and is used to assess areas of executive functioning impairment among youth between the ages of six and 17. The BDEFS-CA offers a long form (70 items) and a short form (20 items) for parent respondents only as well as an interview form based on the short form in the instance the parent is unable to complete the questionnaire. Informants rate the frequency of the youth's behavior on a four-point scale (1 = never or rarely, 2 = sometimes, 3 = often, 4 = very often) and the ratings are totaled. The short form yields a total executive functioning summary score with higher scores suggesting greater executive functioning impairment. The long form assesses five executive functioning domains including Self-Management to Time, Self-Organization and Problem-Solving, Self-Restraint, Self-Motivation, and Self-Regulation of Emotion. It also yields a summary score (the sum of the five domains), a symptom count (the frequency of items rated as "often" or "very often"), as well as an ADHD-executive functioning index score with higher scores suggesting a greater presence of clinically-significant ADHD symptoms.

The BDEFS-CA demonstrates high internal consistency (Cronbach's α = 0.95 to 0.97), high test–retest reliability at two and three weeks across scales (r = 0.73 to 0.82; Barkley, 2011; Barkley & Murphy, 2011). Furthermore, support for the validity of the BDEFS-CA has been well established (Barkley, 2011, 2012, 2014). O'Brien et al. (2021) found the BDEFS-CA demonstrates adequate convergent and discriminant validity with measures of ADHD thereby providing support for the clinical utility of the executive functioning summary score and the ADHD-executive functioning index score in diagnosing ADHD in children.

18.6.4 Brown Executive Functioning/Attention Scales (BROWN EF/A)

The Brown Executive Functioning/Attention Scales (Brown EF/A*;* Brown, 2019*)* is used to assess ADHD symptoms according to *DSM-5* diagnostic criteria as well as impairments in executive functioning in individuals. Executive functioning is measured based on Brown's Model of Executive Functions impaired in ADHD (Brown, 2019). Specifically, executive functioning is measured by six content domains: Activation (i.e., organization/planning), Focus, Effort, Emotion, Memory, and Action (i.e., self-monitoring). The Brown EF/A includes multiple assessment tools including a parent rating form for children ages three to 18, a teacher rating form for children ages three to 12, and a self-report form for individuals ages 13 to adult. The questionnaire can be administered via paper form or electronically through Q-global.

Instead of rating the frequency of a given behavior/symptom, informants rate how big of a problem the client's behavior has been in the past six months on a four-point scale (0 = no problem, 1 = little problem, 2 = medium problem, 3 = big problem). The scores of each item are then summed to create a total composite raw score as well as raw scores for the six content domains. This can be done by hand or by using Q-global. The raw scores for each scale are then converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores indicating atypical and problematic executive functioning which in turn suggests the presence of ADHD symptoms. Specifically, T-scores between 60 and 69 are considered to be subclinical elevations, and T-scores greater than 70 are considered to be clinical elevations.

The Brown EF/A was developed as an updated version of the Brown Attention Deficit Disorder Scales (Brown ADD Scales; Brown, 1996). While both are designed to be screening measures for ADHD, the Brown ADD Scales are based on *DSM-IV* criteria and do not include the Action content domain. Multiple studies have reviewed the validity and reliability properties of the Brown ADD Scales and found it to be an adequate measure for ADHD assessment though Rucklidge and Tannock (2002) found that it had low sensitivity and had better utility in screening out ADHD. The Brown EF/A parent, teachers, and self-report forms are correlated with the BASC-3 PRF, TRF, and SRP, respectively. However, there is limited information regarding the validity of the Brown EF/A. Further research is necessary to determine the clinical utility of the Brown EF/A in ADHD assessment.

18.6.5 Childhood Executive Functioning Inventory (CHEXI)

The Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008) is a 26-item measure used to assess impairment in executive functioning among youth between the ages of four and 12. There is also an adolescent version of the measure (ADEXI) for individuals ages 13 to 18. The CHEXI is an informant-rated measure typically completed by parents and teachers while the ADEXI is a self-report measure. Informants rate the frequency of the client's behavior on a five-point scale (1 = definitely not true, 2 = not true, 3 = partially true, 4 = true, 5 = definitely true), and the examiner scores the measure by hand. Items are summed to their relevant scales with higher scores indicating higher impairment in areas of executive functioning. Executive functioning is measured by four different subscales: working memory, planning, regulation, and inhibition. Raw scores for the Working Memory and Planning subscales are summed to form the Working Memory Total Score while raw scores for the Regulation and Inhibition subscales are summed to form the Inhibition Total Score. The CHEXI demonstrates good test–retest reliability and internal consistency (Thorell & Nyberg, 2008). Additionally, the CHEXI has been found to discriminate well between children with and without ADHD

(Thorell et al., 2010). This suggests that the CHEXI is a suitable measure in assessing executive dysfunction to supplement ADHD assessment.

18.6.6 Continuous Performance Tests

18.6.6.1 Conners' Continuous Performance Test-Third Edition

The Conners' Continuous Performance Test-Third Edition (Conners' CPT-3; Conners, 2014) is a continuous performance test that assesses aspects of attention related to ADHD in individuals ages eight and older. It is a 14-minute computer-based test that requires the client to press the spacebar when any letter besides "X" appears. Following test completion, a score report is generated. This report provides an assessment of the four major domains: inattentiveness, impulsivity, sustained attention, and vigilance based on their task performance. Additionally, reaction time statistics (i.e., hit reaction time, hit reaction time block change, variability, etc.), detectability (i.e., how easily the client differentiates between targets and non-targets), error rates (i.e., omissions, commissions, and perseverations), and a validity report are also provided.

The raw scores for each scale are converted to T-scores (M = 50, SD = 10) based on an age and gender normative sample with higher scores indicating executive functioning impairment. In measuring the majority of domains, T-scores between 60 and 69 suggest elevated impairment, and T-scores greater than 70 indicate very elevated impairment. For hit reaction time statistics, T-scores between 60 and 69 suggest slower performance than expected, and T-scores greater than 70 indicate atypically slow performance. Furthermore, T-scores between 40 and 44 suggest faster performance than expected, and T-scores less than 40 indicate atypically fast performance. Individuals with ADHD exhibited poorer performance (i.e., higher scores) and made more errors on the Conners CPT-3 (Conners, 2014). Additionally, individuals with ADHD exhibited more difficulty distinguishing between distractors and relevant stimuli and showed more variability in their responses overall (Conners, 2014). These findings suggest that the Conners CPT-3 is a useful measure in evaluating the presence of ADHD symptoms.

18.6.7 Test of Variables of Attention

The Test of Variables of Attention-Ninth Edition (TOVA-9; Greenberg et al., 2020) is another continuous performance test that assesses aspects of attention related to ADHD. It is a computer-based test that requires the client to respond to a target stimulus and ignore distractor stimuli. Audio and visual versions of the test are offered for individuals ages six and older, and there is a shorter version of the visual TOVA-9 offered for children ages four and five. The TOVA-9 for children ages four and five lasts approximately 11 min while the version for individuals ages six and older lasts approximately 22 min. The first part of the TOVA-9 is referred to as a "target infrequent" half in which there are significantly more distractor stimuli presented than target stimuli, and the second half of the TOVA-9 is referred to as the "target frequent" half in which the target stimulus is presented more often than the distractor stimuli.

After the test concludes, a score report is generated and yields results regarding the client's response time, response time variability (i.e., consistency), and errors (i.e., commission and omission). The raw scores for each scale are converted to T-scores (M = 100, SD = 15) based on an age and gender normative sample with higher scores indicating higher impairment. Specifically, T-scores between 80 and 85 are considered to be borderline, and T-scores less than 80 are considered to not be within normal limits. An Attention Comparison Score is also calculated which compares the individual's performance to a sample of individuals diagnosed with ADHD. Scores below zero indicate similar performance to the ADHD group while scores above zero indicate similar performance to the normative sample. It also calculates secondary measures including anticipatory responses, post-commission response time, and multiple responses.

The TOVA-9 discriminates well between individuals with and without ADHD (Leark et al., 2000); thus, its inclusion in ADHD assessment is beneficial. However, Lin et al. (2023) found gender differences in performance between the visual and audio versions of the TOVA-9 in boys and girls with ADHD. Specifically, boys with ADHD were overall more impulsive than girls with ADHD on both versions of the TOVA-9 while girls with ADHD displayed more auditory inattention than boys with ADHD. This finding presents clinical implications as it has been found that ADHD is overdiagnosed in boys than girls and should be considered when incorporating this measure into an evaluation (APA, 2022; Nigg & Barkley, 2014; Polanczyk et al., 2007).

18.7 Case Conceptualization

The case conceptualization process begins once the clinician has administered and completed all of the selected interviews, tests, and measures. The clinician must review and integrate all of the information and details yielded from this process. The clinician should incorporate details regarding the child's age and environmental background, the number and presentation of inattention and hyperactivity symptoms exhibited by the child, how long the symptoms have persisted, and the settings in which these symptoms persist. For example, young children are often more hyperactive than older children or adolescents. In this case, the clinician should determine whether the presentation of symptoms is greater in frequency or more impairing than expected given the child's age, culture, and environment.

Additionally, these symptoms must cause significant impairment or interference with the child's daily functioning. While mild experiences of trouble focusing or paying attention are normative across the lifespan, individuals with ADHD experience significant functional impairment as a result of their inattention and/or hyperactivity symptoms. For instance, children with ADHD often experience significant problems in their academic and social functioning as a result of the severity of their symptoms (Lollar, 2008). Collecting data from multiple reporters can help clinicians determine whether symptoms of inattention are more severe, frequent, or impairing than normative. However, this may pose a challenge for clinicians if the information gathered is variable or inconsistent. For instance, there may be a discrepancy in reporting related to how well the informant knows the child or the impact of the environmental setting in which the informant is with the child (Hamblin et al., 2016; Jensen et al., 1999). However, discrepant reporting does not negate the presence of a psychological disorder. Rather, these factors are important considerations for clinicians to incorporate into their conceptualization in an effort to increase validity.

Furthermore, inattention and hyperactivity symptoms must be present in two or more settings for at least six months and prior to age 12 in order to receive an ADHD diagnosis. Therefore, if symptoms of inattention and/or hyperactivity reportedly occur inconsistently and have not been present since early childhood, an ADHD diagnosis is not appropriate. Lastly, the clinician must determine whether the etiology of the presenting inattention and hyperactivity symptoms is consistent with ADHD symptomatology and not better explained by alternate problems or different psychopathology. This may pose another challenge for the clinician as inattention and hyperactivity symptoms may be indicative of various mental disorders. Similar symptom presentations may influence the results of various assessment tools and negatively affect diagnostic accuracy. Thus, an understanding of psychological disorders that commonly co-occur with ADHD is important and necessary in ADHD assessment.

18.8 ADHD and Other Neurodevelopmental Disorders

Researchers have demonstrated overlap between various neurodevelopmental disorders, which are a group of conditions with onset in the developmental period (APA, 2022). For example, difficulties with executive functioning, such as planning, goal setting/achievement, flexibility, and observation, are often observed in individuals with ASD and/or intellectual disability (ID; Klein et al., 2020; van der Meer et al., 2012). The phenotypic overlap and possible genetic similarities across the three disorders are discussed below.

18.8.1 Autism Spectrum Disorder

ASD is characterized by persistent deficits in social communication and interaction across multiple contexts (e.g., social reciprocity, nonverbal communication, and skills in developing, maintaining, and understanding relationships) as well as the presence of restrictive, repetitive patterns of behavior, interests, or activities (APA, 2022). Though ADHD and ASD are separate diagnoses, both share similar traits and symptoms, are common neurodevelopmental disorders, and carry a genetic risk.

The growing literature also indicates some overlap in neuropsychological, neuroimaging, and genetic loci associated with the two (Nigg & Barkley, 2014). Moreover, findings suggest that shared genetic influences may explain some of the phenotypic similarities between ADHD and ASD traits. For example, twin studies suggest shared genetic components between traits of the two disorders, with correlations significantly increasing throughout the lifespan (Reiersen et al., 2008; Ronald et al., 2008, 2010). Similarly, researchers suggest that over half of the individuals with ASD experience clinically significant levels of co-occurring inattention and/or hyperactivity (van der Meer et al., 2012), providing further support that ADHD and ASD may have shared etiologies. The APA (2013) incorporated these findings in the publication of *DSM-5*, which allows for the co-diagnosis of ADHD and ASD, to create congruence between diagnostic criteria and recent empirical evidence (Nigg & Barkley, 2014).

18.8.2 Intellectual Developmental Disorder (Intellectual Disability)

Intellectual developmental disorder (ID) is characterized by broad deficits in mental abilities (e.g., abstract thinking, judgment, academic learning, reasoning) and adaptive functioning (i.e., conceptualization/communication, socialization, independence) that result in failure to meet developmental and sociocultural standards for personal independence and social responsibility (APA, 2022). Despite evidence of some phenotypic overlap between intellectual disability and ADHD, no etiological similarities have been identified.

Researchers have shown that ADHD is more common in children with ID and that the risk increases with the increasing severity of intellectual disability (Voight et al., 2006). Although ADHD and ID share some common phenotypic traits, available literature regarding the clinical presentation and etiology of ADHD in children with ID is scarce as those with cognitive deficits (IQ scores <70) are often excluded from clinical, etiologic, and treatment studies (Lindsey, 2002). However, a recent study by Klien and colleagues (2020) found a set of autosomal intellectual disability genes ($N = 396$) to be significantly associated with ADHD risk in both discovery and replication data sets. The same study identified three ID-related genes (i.e., *MEF2C*, *ST3GAL3*, and *TRAPPC9*) associated with ADHD risk. The authors further characterized and validated these findings in *Drosophila melanogaster* (common fruit fly), indicating that genes affected by this rare genetic variation in individuals with intellectual disability may contribute to ADHD risk through shared genetic variants (Klein et al., 2020). This novel evidence paired with the established phenotypic overlap of ADHD and intellectual disability warrants further exploration regarding possible common etiologies between the two.

18.9 Differential Diagnoses

As noted above, neurodevelopmental disorders frequently co-occur with one another. Similarly, ADHD is often comorbid with other childhood-onset mental and behavioral disorders (e.g., ASD, ODD, CD, specific learning disorder). Therefore, it is essential that clinicians are able to differentiate between these disorders when making a diagnosis.

18.9.1 Autism Spectrum Disorder

These two disorders frequently co-occur with one another, with ADHD presenting in 30–80% of individuals with ASD, and ASD presenting in 20–50% of individuals with ADHD (van der Meer et al., 2012). It is also common for individuals to have cross-disorder symptoms without meeting the clinical criteria for diagnosis (Ronald et al., 2008). ASD may initially be difficult to discriminate from ADHD due to similar symptom presentation patterns (e.g., social communication impairments, difficulty focusing/intense focus, language skills challenges, executive functioning issues, sensory overload, hyperactivity/impulsivity, and lack of eye contact) in young children. However, the increased motoric activity associated with ADHD is typically generalized across settings, and these behaviors are not characterized by repetitive stereotypic movement observed in some cases of ASD (APA, 2022). Similarly, while attention problems occur in both disorders, the inattentiveness associated with ADHD pertains to difficulty with sustained attention and is not due to defiance or a lack of comprehension, whereas ASD is associated with deficits in joint or divided attention (Villegas, 2016). Observation of the developmental course and the absence of restricted, repetitive behaviors and unusual interests can help differentiate between the two (APA, 2022).

18.9.2 Intellectual Developmental Disorder (Intellectual Disability)

Researchers indicate that the comorbidity of intellectual disability and ADHD is 8–39%; however, ADHD in those with intellectual disability may be underdiagnosed and misdiagnosed due to various patient and clinical factors (e.g., communication difficulties, limited symptom effects due to disability, limited published research; Ahuja et al., 2013; Sawhney et al., 2021). Further, diagnosing ADHD in this population can be challenging due to the overlapping psychological and behavioral symptom presentations. Individuals with intellectual disabilities in the mild range may experience similar symptoms to those with ADHD, such as difficulty with executive functioning (e.g., distractibility, attention problems), short-term memory, and functional use of academic skills (Klinger et al., 2014). While the difficulties faced by those with intellectual disability may present themselves similarly to those with ADHD, the difference lies within the core deficits of the disorders as ADHD is characterized by a lack of inhibitory control rather than a broad deficit in mental abilities (APA, 2022). In individuals with ADHD, performance increases to a normal level when attention problems are controlled but remains low in those with intellectual disability (Villegas, 2016). As attention is often considered a determinant of intelligence, a diagnosis of ADHD in individuals with intellectual disability requires that symptoms of inattention be in excess of their mental age (APA, 2013).

18.9.3 Specific Learning Disorder

Among individuals with ADHD, over half meet the criteria for a specific learning disorder which refers to a significant deficit in learning or applying academic skills in reading, math, and writing (APA, 2022; Gnanavel et al., 2019). Learning disorders affect one of the four primary processes required for learning (i.e., recording, understanding, storing, and retrieving information) and significantly interfere with one's academic performance. Children with specific learning disorders alone may appear inattentive in situations that require the impaired cognitive process; however, their inattention subsides when the impaired process is not required (APA, 2022). Conversely, it is the impulsivity, hyperactivity, and distractibility that interfere with the learning process in those with ADHD, not a specific disorder in reading, math, or writing abilities that impacts one of these processes.

18.9.4 Disruptive Behavior Disorders

The co-occurrence of ADHD with other externalizing disorders can greatly impact the individual's functioning. ODD occurs in up to 60% of children with ADHD (Noordermeer et al., 2017). Symptoms of ODD must be differentiated from aversion to certain tasks or situations due to difficulty in sustaining focus or behavioral inhibition (APA, 2022). CD co-occurs with ADHD in as many as 25–45% of youth, depending on age and setting (APA, 2022, Children and Adults with Attention-Deficit/Hyperactivity Disorder, 2023). Many children with CD also present with symptoms of ADHD and difficulty with attention or hyperactivity-impulsivity. Thus, it is important to note that while children with ADHD may be disruptive to their teachers and peers, aggression is not a core symptom of the disorder. Rather, some children may develop secondary aggressive behaviors due to problems with emotional regulation and control (Saylor & Amann, 2016).

18.9.5 Mood Disorders

Researchers indicate that 10–30% of children with ADHD have a co-occurring mood disorder (e.g., depressive disorders, bipolar disorder, disruptive mood dysregulation disorder; CHADD, 2023; Gnanavel et al., 2019). Individuals with depressive and/or bipolar disorders may report intense emotions, irritability, and abnormal sleeping patterns as well as impulsive, inattentive, and hyperactive behavior (APA, 2022; Comparelli et al., 2022). However, these behaviors are episodic, whereas symptoms of ADHD are chronic. Though most youths with disruptive mood dysregulation disorder also meet symptom criteria for ADHD, impulsivity, and disorganization are not core symptoms of the disorder (APA, 2022).

18.9.6 Anxiety and Trauma-Related Disorders

Additionally, researchers suggest that anxiety disorders may affect over 25% of individuals with ADHD (Gnanavel et al., 2019; Higa-McMillan et al., 2014). Additionally, evidence suggests that trauma-related disorders may occur more frequently in individuals with ADHD than those without ADHD, though statistics and debates vary across studies (Gnanavel et al., 2019; Nader & Fletcher, 2014). Though symptoms of anxiety may overlap with those of ADHD, such as unpredictable mood swings, excessive irritability, frequent angry outbursts, low energy levels, aversion to new tasks, and inattention, these symptoms in ADHD are not due to rumination or excessive worry (APA, 2022). Similarly, both ADHD and trauma-related disorders (i.e., acute stress disorder, post-traumatic stress disorder) may include problems regarding attention, concentration, and learning as well as hyperactivity and difficulty sleeping (Siegfried et al., 2016; Thomas, 1995). As these similarities often make obtaining a correct diagnosis difficult, the onset and cause of problem behaviors can be helpful in differentiating between the two. Symptoms of trauma-related disorders may be attributable to hyperarousal or dissociation when reminded of events and have their onset following exposure to a traumatic event whereas symptoms of ADHD must be present prior to age 12 (APA, 2022).

18.10 Summary

ADHD refers to a persistent pattern of clinically significant inattention and/or hyperactivity symptoms (Pinzone et al., 2019; Willcutt et al., 2012). It is the most common neurodevelopmental disorder among children and adolescents, and it is associated with significant impairment and negative outcomes across the lifespan (Barkley et al., 1990b; Lollar, 2008; Mick et al., 2004). Evidence-based assessment is helpful in identifying individuals with ADHD and referring those individuals to proper treatment resources (DuPaul et al., 2020).

Mash and Hunsley (2005) recommend using evidence-based measures in ADHD assessment in order to increase diagnostic accuracy. The purpose of this article is to describe and empirically review various assessment methods with established psychometric properties in order to inform reliable and valid ADHD assessments. The assessment process should involve unstructured as well as structured or semi-structured diagnostic interviews. These methods help to determine the child's history and environment, which symptoms of inattention and hyperactivity are present, when these symptoms emerged, how often the symptoms occur, and ways that they significantly interfere with the child's daily functioning. Additionally, the utilization of questionnaires is also helpful in determining the severity of the child's symptoms as well as incorporating information from multiple informants. Special considerations should be taken by the clinician when integrating discrepant reports from multiple informants such as the role of the informant, the informant's familiarity with the child, and the effects of the environment on the informant's perception of the child. Administering tests and measures of executive functioning are also beneficial in ADHD assessment. Although executive dysfunction is not a core mechanism in ADHD symptomatology, there is significant overlap between the two, and studies have found that the inclusion of executive functioning measures such as the ones reviewed in this chapter increases the accuracy of ADHD assessment (Jarrett et al., 2018; Nikolas et al., 2019; Tallberg et al., 2019).

Once the clinician has gathered the necessary information and completed test administration, the case conceptualization process begins. This involves the clinician comparing the child's symptoms to the *DSM-5* ADHD diagnostic criteria to determine whether the child's experiences fit the ADHD symptom profile. In this process, the clinician should consider community base rates and common comorbid diagnoses to ensure diagnostic accuracy. The clinician should make special considerations when ASD or ID symptoms co-occur as these disorders frequently co-occur and share related but distinct symptom profiles. Suhr (2015) recommends that clinicians consider all possible hypotheses for why these symptoms are occurring and continuously update their hypotheses to avoid confirmation bias.

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19 Self-Report Measures for Assessing ADHD in Adults

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While there has been some vigorous recent discussion around the issue of a potential adult-onset variant (e.g., Hartung et al., 2022; Sibley et al., 2018; Solanto, 2021), attention-deficit/hyperactivity disorder (ADHD) is generally understood to be a disorder that emerges in childhood or early adolescence. The *Diagnostic and Statistical Manual of Mental Disorders* (*5th edition text revision;* DSM-5-TR, American Psychiatric Association, APA, 2022) establishes formal criteria for diagnosis, including a threshold for symptomatic expression and related impairment, duration of symptoms, guidance to rule out other potential underlying disorders or life circumstances, and the age of onset criterion. Currently, the latter specifies that several symptoms (inattention and/or hyperactivity-impulsivity) must be present prior to age 12.

For clinicians assessing potential ADHD, in the majority of cases, documenting the presence of early symptoms is not too complicated. This is, of course, because the most common timing of diagnosis is in childhood or adolescence (APA, 2022), and there are well-qualified informants (i.e., parents, other guardians, and teachers) in the vast majority of such cases who can provide observational information regarding a client's behavior. One of the most common ways that such behavior is indexed is on parent- or teacher-report questionnaire measures of ADHD, such as the *Conners* scales (*3rd edition*; Conners et al., 2008). The *Conners* is in fact an excellent example of a scale that has evolved and improved over time, boasting extensive validation and norming as well as additional scales for common externalizing comorbidities and three validity indices. While the overall endeavor of diagnostic decision-making, as in all assessment cases, is complicated and involves ruling out other conditions whose symptoms might mimic those of ADHD (e.g., anxiety, mood, and learning disorders), the presence of multiple informants and a plethora of well-established measures (as reviewed in Mulraney et al., 2021) is quite helpful to clinicians working with child and adolescent clientele.

The first-time assessment for ADHD in clients who have reached adulthood is, for various reasons, more complicated and, arguably, more problematic. First among its specific challenges is that the assessment of present (e.g., past 6 months) *and* sometimes-long-past behavior (e.g., from 5 to 12 years of age) and adjustment are necessary. This alone introduces several possible confounding factors. Regarding reports of past behavior and adjustment, qualified informants may not be readily available. Parents or older siblings may be geographically distant, estranged, or deceased, and elementary- or middle-school teachers are even less likely to be productive sources for an adult client's assessment. Such

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possible informants, even when available, can possibly be antagonistic to the process, either believing that ADHD itself is a hoax, that everything is "fine" for the client, or that the client should just work harder and complain less. Contributing to such thoughts may be the childhood performance of the evaluee in school; it is at least sometimes the case that those diagnosed with ADHD in adulthood were able to perform reasonably or even quite well due to other factors (e.g., high intelligence, low demands in school, structure of parents/home), and informants may remember such results more than underlying symptoms. In any event, reports from individuals holding such views, despite the concerns of related adult clients, are unlikely to have questionable validity. In the end, the most appropriate and available informant, in many cases, is the client themselves, especially regarding childhood ADHD symptoms. Unfortunately, there are drawbacks to reliance on retrospective self-reports, including inaccurate recall, an issue that will be touched on again below.

Second, the manifestation of ADHD is different in adults than it is in children. This is something that should come as no surprise; it is recognized in other disorders that can be present in both children and adults that symptomatic expression can vary substantially across the lifespan. For example, the demonstration of persistent and abject sadness is sometimes not noted in children with major depression, with irritability being more indicative of the mood disorder (APA, 2022). Regarding ADHD, developmental differences have also been noted. For instance, excesses in hyperactivity that emerge in childhood wane substantially during adolescence and early adulthood, whereas inattention and aspects of impulsivity tend to have greater longevity (Biederman et al., 2000). In addition, some research suggests that deficits in executive functioning may be more diagnostic of ADHD-related impairment by adulthood (Barkley et al., 2007; Fedele et al., 2010). However, up until the release of *DSM-5* (APA, 2013), the diagnostic symptoms and other criteria utilized for identifying children with ADHD were identical to those used for the assessment of adults. While the change is welcome and reflects the evolution of ADHD expression in many cases, the added parenthetical "qualifiers" for adult ADHD symptomatology were not based on empirical observations but instead on the consensus of the *DSM-5* expert committee. All of this suggests a couple of things: (a) that older assessment measures (including self-reports) may not benefit from the emerging trend of recognizing differences between ADHD in children and adults and (b) that more generally, there may be some disparity across measures in terms of level of sophistication in capturing adult ADHD-related pathology.

Third, there is a real possibility that the motivation of adults seeking a diagnosis is different from that of children or younger adolescents, and this may impact assessment. Parents are the ones who need to be made to feel motivated regarding the assessment of their children, which is often facilitated by comments and referrals from teachers, coaches, health care providers, and/or other concerned adults who either desire better-managed situational behavior or to see the child meet their full potential (or both). Perhaps, obviously, it could well be that in many such cases, the child themselves does not feel *motivated* to achieve a diagnosis and, in some cases, may in fact desire *not* to be diagnosed, stemming from concern about what others may think of them (Mueller et al., 2012). In the case of adult assessment clients, however, there are likely substantial and differing internal motivations. Some may simply be seeking diagnostic assessment to better know themselves, either to put past difficulties into an appropriate perspective or to appropriately plan for the future. Others recognize that current struggles in school, work, or relationships may have an underlying psychological cause and, in turn, think that a diagnosis can lead to concrete solutions, such as accommodations, medication, or therapy. Still others may be trying to "game the system" for various reasons, either to gain perceived (e.g., school accommodation) or real (e.g., disability compensation) advantages or to obtain medication for illicit use, either on their own or for diversion to others, something that is rampant in emerging adult college students, particularly (Lovett & Harrison, 2021). When combined with the observed trend that emerging adults without ADHD may *over*report their experience of ADHD symptoms (Sibley et al., 2012), this raises the specter of possible malingering in adult clients. While such behavior is quite likely not commonplace, assessment techniques for adult ADHD should ideally account for that possibility.

Keeping these and other issues in mind, self-report measures are a mainstay component of evaluation for adults presenting with symptoms of or concerns about possible ADHD (Lefler et al., 2021). In clinical practice, self-reports represent just a facet of the clinical diagnostic and decision-making process (Faraone & Antshel, 2008). Self-report measures are most typically thought of as means to document the presence or absence of ADHD symptoms, or, in other words, to test the *DSM* Criterion A for diagnosis. There is evidence that, in adults, self-reports on ADHD symptom checklists correspond highly with prior diagnoses of ADHD, suggesting the possibility of diagnostic utility for previously unevaluated individuals (e.g., O'Donnell et al., 2001). There are issues, however, in over-reliance on self-reports as decisive evidence in this regard, such that some (e.g., Harrison et al., 2019; Sibley, 2021) suggest that the place of self-reports in a "gold-standard" assessment may primarily be screening tools whose results are then tested more rigorously in a standardized clinical interview for ADHD, data collected from other informants (e.g., parents, siblings, and partners), and, possibly, objective measures of inattention and/or hyperactivity-impulsivity (e.g., Test of Variables of Attention, TOVA; Greenberg, 2011). More attention will be given to this particular issue below. Regardless, it is certainly the case that self-report ADHD measures are used regularly in research, either in the service of "full" clinical diagnosis of participants or as measures that establish the dimensional distribution of ADHD traits in a given population.

Whether one is interested in clinical or research endeavors, it is obviously of some importance to select a self-report ADHD measure (or measures) that provides the desired information regarding symptoms and related impairment; ideally, perhaps, additional information (e.g., regarding executive functioning) would also be gleaned. We would suggest that it is of equal importance to understand the relative evidence of reliability and validity for any candidate measure. The bulk of the remainder of this chapter will focus on reviewing the currently available self-report ADHD measures in this light.

19.1 Descriptions of Self-Report Measures for ADHD Assessment in Adults

Given the *DSM-5-TR* criteria of the presence of at least five symptoms of ADHD-related inattention (IA) or hyperactivity-impulsivity (HI) in the past 6 months and several symptoms present before the age of 12, establishing these is an integral part of the evaluation for any adult client presenting with ADHD-related concerns. As noted, one of the means of establishing symptomatic presence is via self-report measures of ADHD symptoms (APA, 2022). There are several measures that fit the bill, are widely used, and can be easily accessed by both clinicians and researchers. A summary of such measures follows.

19.1.1 ADHD Symptom Checklists

A straightforward, convenient method of assessing symptoms is checklists that simply tap the nine IA and nine HI symptoms denoted in the *DSM-5-TR*. Such measures can focus on the retrospective report of past childhood symptoms, such as the 18-item Barkley Childhood Symptoms Scale (CSS; Barkley & Murphy, 2006; Hartung et al., 2016). Responders indicate the frequency of each symptomatic behavior from ages 5–12, with item responses on a 4-point scale (0 [*not at all*], 1 [*sometimes*], 2 [*often*], and 3 [*very often*]). Items that are rated *often* or *very often* are considered endorsed symptoms (Guldberg-Kjär & Johansson, 2015). Barkley also published a companion 18-item measure for current ADHD symptoms (i.e., Barkley Current Symptoms Scale, Barkley, 1998) with an identical format.

Other checklists are primarily focused on current adulthood symptoms, such as the 18-item ADHD Rating Scale-IV (ADHD-RS-IV; DuPaul et al., 1998; Mitchell et al., 2009) and the 18-item Adult ADHD Self-Report Scale (ASRS; Fuller-Kilgore et al., 2012; Kessler et al., 2005). The ADHD-RS-IV assesses each *DSM-IV* (APA, 1994) symptom during the past 6 months, and includes additional prompts to determine severity. It can be adapted for the assessment of both children and adults; however, it should be noted that normative data for adults is sparse compared to that for children (Ramsay, 2015). Items on the ASRS are rated on a scale from 0 to 4 (*never, rarely, sometimes, often, very often*; Fuller-Kilgore et al., 2012). Six of the 18 items on the ASRS have been found most predictive of an ADHD diagnosis and comprise a short-form screener (ASRS-S) for ADHD symptoms in adulthood during the last 6 months. Four items assess inattention symptoms and two assess HI symptoms (Fuller-Killgore et al., 2012; Green et al., 2019), and a screened case is considered "positive" if at least four items are rated as "sometimes" or "often" (Kessler et al., 2005; Lovett et al., 2021). A particular advantage of the ASRS-S is that it has been specifically revised and examined as an ADHD screener for adults that maps onto the relatively new *DSM-5* symptom criteria that include parenthetical additions for older clients (Unstun et al., 2017).

Many measures assess both childhood and current symptoms, such as the 18-item Assessment of Hyperactivity and Attention (AHA; Mehringer et al., 2002). Items on this measure regarding childhood until age 12 are presented first, and then items regarding adulthood symptoms are presented second; thus, symptoms are organized into four categories: childhood IA, childhood HI, adult IA, and adult HI. The presence of either childhood or current ADHD is indicated by the endorsement of at least six symptoms in any category. Of note, the ADHD-RS and AHA are both based on the *DSM-IV* criteria, so it is important to utilize updated diagnostic specifications when administering such checklists today. As a reminder, related revisions to the ADHD definition in *DSM-5-TR* warrant attention in utilizing any non-current measures of assessment, including: (a) one less symptom is required (i.e., five instead of six) to be currently present for older adolescents and adults (i.e., age 17 or older), (b) the age of onset for symptoms was raised from age seven to 12, and (c) additional parenthetical descriptions are provided for several symptoms detailing how the symptom may appear differently in adults (Epstein & Loren, 2013).[1]

While all of the above measures are "named" and have undergone some greater or lesser degree of validation and use, one of the perhaps evident potential shortcomings is that published diagnostic measures can be slow to have revisions that keep them current as *DSM* versions change. This is observed, unfortunately, in the case of ADHD and the parenthetical updates to symptom verbiage in the *DSM-5*. Researchers and clinicians alike are likely utilizing "home-brew" instruments that either use a well-tried scale (e.g., *never/sometimes/often/very often*) or a simple dichotomous ("yes" or "no") response to each of the verbatim *DSM-5* items. For instance, Hartung et al. (2022) utilized an ADHD-symptom checklist measure adapted directly from the *DSM-5* items, utilizing a 4-point scale, and it achieved its purpose of obtaining symptomatic data from clients while demonstrating satisfactory internal reliability. This particular measure had been used previously in the study of a large college student population, achieving robust internal reliability there as well (Lefler et al., 2020). As such, the reader could seriously consider utilizing a similar,

[1] Other changes to diagnostic criteria were also made in the *DSM-IV-TR to DSM-5* transition, but they concern the aspects of pervasiveness and impairment of symptoms, rather than the symptoms themselves.

basic *DSM-5* symptom rating checklist for their own assessment purposes.

Regardless of one's choice, a concern with symptom checklists arises from item organization, in that the nine IA and nine HI symptoms can either be listed in alternating order (i.e., IA, HI, IA, HI) or with each set of nine symptoms listed together as separate dimensions. Mitchell et al. (2009) found that, when presented symptoms in an alternating list, people who rated one symptom highly were more likely to rate the next item from the opposite symptom dimension highly as well. This resulted in a high correlation between the IA and HI symptom dimensions, although they found good internal consistency for each dimension individually. It does perhaps suggest, though, that measures including items grouped by subscale (i.e., 9 IA items, then 9 HI items) may be preferable and that home-brewed instruments may be best when adapting this format, too. To illustrate variability in published measures, the aforementioned AHA (Mehringer et al., 2002) and ADHD-RS-IV (DuPaul et al., 1998; Mitchell et al., 2009) are both organized with items grouped sequentially according to symptom cluster (i.e., IA, HI). Items on the Barkley Childhood and Current Symptoms Scales (Barkley, 1998; Barkley & Murphy, 2006), on the other hand, alternate between IA and HI symptoms.

19.1.2 Broader ADHD Symptom Inventories

Another sort of measure that is available to tap ADHD symptomatology and that tends to boast established, normative reference samples and a broader array of psychopathology measures are broader-based symptom inventories. One such measure for both childhood and current symptoms is the 30-item Barkley Adult ADHD Rating Scales-IV (BAARS-IV; Barkley, 2011a; Dehili et al., 2013; Kamradt et al., 2014). Items are rated on a 4-point scale based on symptom severity, from 1 (*minimal*) to 4 (*very often*), with ratings of three serving as the threshold for an endorsed symptom (Ramsay, 2015). The BAARS-IV provides norm-based scores for total ADHD and symptom counts overall, as well as within each of the symptom clusters: IA, impulsivity, and hyperactivity, similar to the adult version of the CSS noted above. What adds breadth to this measure is a subscale measuring adulthood symptoms of sluggish cognitive tempo (SCT), a putative second attention-deficit condition (Barkley, 2013) that is characterized by difficulties regulating and activating attention, effort, and alertness (Ramsay, 2015). While relatively sparse research exists on SCT, research has not only shown that SCT symptoms are separate from but also significantly correlated with symptoms of ADHD (Barkley, 2015) and, even on their own, are associated with significant life impairment (Barkley, 2012; Combs et al., 2014; Flannery et al., 2017). This appears to support the added items to assess SCT on the BAARS-IV. Finally, the BAARS-IV also features a very brief measure of functional impairments, categorically in four domains (Home, Education, Work, and Social), using one item each. While this adds to the utility of the measure, we generally suggest utilizing a more comprehensive measure of impairment for better case conceptualization and treatment planning, some of which are detailed below.

One of the most commonly used inventories for the assessment of adult ADHD is the Conners' Adult ADHD Rating Scales (CAARS; Conners et al., 1999), which offers self- and observer-report forms and is available in both long (i.e., 66 items), brief (i.e., 30 items), and screening (i.e., 28 items) versions. This measure also includes an Inconsistency Index, derived from comparing an individual's responses on eight pairs of similar items to determine the consistency of their responses. Of note, the CAARS is based on *DSM-IV* criteria, and item wording has not been updated for the newer *DSM-5-TR*, with no updates to normative data since 1998 either. Items are rated on a 4-point scale from 0 (*not at all*) to 3 (*very much, very frequently*), and the measure does provide norm-based scores according to an individual's gender and age, including a total score and several subscale scores (Ramsay, 2015). In fact, eight subscales based on various difficulties commonly associated with ADHD are scored: Inattention/memory problems, hyperactivity/restlessness, impulsivity/emotional lability, problems with self-concept, *DSM-IV* inattentive symptoms, *DSM-IV* hyperactive-impulsive symptoms, *DSM-IV* ADHD symptoms total, and ADHD index (Fuller-Kilgore et al., 2012; Kooij et al., 2008; Ramsay, 2015; Rösler et al., 2006). Shorter versions of the CAARS include fewer subscales, focusing primarily on those assessing *DSM* criteria directly.

Another notable inventory is the 40-item Brown Attention-Deficit Disorder Scales for Adults (BADDS), on which items are also rated on a 4-point scale from 0 (*never*) to 3 (*almost daily*; Fuller-Kilgore et al., 2012; Kooij et al., 2008; Ramsay, 2015). Both self- and observer-report versions are available, but norms are only available for self-report. The BADDS, while widely used, was developed before the availability of *DSM-IV* ADHD criteria. As such, it focuses heavily on inattention symptoms and less so on hyperactivity and impulsivity (Rösler et al., 2006). It also includes several items that pertain specifically to executive functions (EF), tapping abilities such as organizing work, managing affective interference, sustaining energy, and effort and working memory, which can lend valuable insight into potential areas of functional impairment. Norms for total item endorsements and five subscales based on components of EF (i.e., Activation, Attention, Effort, Affect, and Memory) are published (Brown, 1996). In a sample of adults from the Netherlands referred for an ADHD assessment, the BADDS was found to be one of the best-performing instruments for diagnosing ADHD when compared to several other measures, including the CAARS, the ADHD Rating Scale, and a structured diagnostic interview (Kooij et al., 2008). In fact, while the CAARS exhibited the highest number of missed diagnoses (39.1%), the BAADS missed less than half that (15.6%).[2]

The 61-item Wender Utah Rating Scale (WURS; Ward et al., 1993) is a larger measure of childhood behaviors that relate to psychopathology, but it contains a subset of 25 items that directly assess ADHD symptoms and associated features (Ramsay, 2015), often referred to as the WURS-25. The WURS-25 items were selected from the larger measure as they evince the greatest mean difference between individuals diagnosed with ADHD and those without ADHD (Kouros et al., 2018). Sample items include, "As a child, I was (or had): concentration problems, easily distracted," "nervous, fidgety," "acting without thinking, impulsive," and "losing control of myself" (Caci et al., 2010). The WURS, along with the Conners' Adult ADHD Rating Scale (CAARS; Conners et al., 1999, see below), is one of the most widely used measures for identifying potential ADHD in adults (Taylor et al., 2011). The salient advantages of the WURS-25 are its relative brevity and the fact that the composition of its items eliminate items that may only apply to specific genders (Calamia et al., 2018; Gift et al., 2021). WURS items are rated on a scale from 0 (*not at all/slightly*) to 4 (*very much*); while somewhat lower cutoffs have been supported in prior research (e.g., see Canu & Carlson, 2007), a score of 46 is indicated and has traditionally been utilized by researchers as a signal of ADHD during childhood (Canu & Carlson, 2003; Gift et al., 2021; Ward et al., 1993), suggesting its potential use as a criterion in clinical assessment as well. It is of note, however, that the wording of WURS items is not verbatim *DSM* criteria (of any edition).

A broader measure that provides subscores related to ADHD is the Behavior Assessment System for Children, Third Edition (BASC-3), which has a version available for adults up to age 25 in self- and informant-report forms (Reynolds & Kamphaus, 2015). Specifically, this self-report college-age form (BASC-3-SRP-COL) is made up of 192 items, and included are scales such as Attention Problems, Hyperactivity, Executive Functioning Content, and the Inattention/Hyperactivity Composite Scales. The Attention Problems scale assesses difficulties maintaining attention and a tendency for

[2] Utility of the CAARS for correctly identifying cases of ADHD in college students has been questionable in other studies, as well (Harrison et al., 2019).

distractibility. The Hyperactivity scale specifically measures hyperactivity, impulsivity, and related behaviors associated with ADHD. The Executive Functioning Content Scale provides an overall measure of behavioral control, organization, planning, utilizing a stepwise problem-solving approach, and decision-making. Finally, the Inattention/Hyperactivity Composite Scale provides a cluster score from the scales most associated with ADHD symptoms, such as those listed above (Reynolds & Kamphaus, 2015). A notable strength of the BASC-3-SRP-COL when scored utilizing the online scoring program, QGlobal, is that it provides a 1:1 representation of endorsed items to the *DSM-5-TR* ADHD symptom criteria. Still, the BASC is a tool that could provide screening and, as needed, corroborating data (e.g., scaled scores) regarding ADHD as well as several other common disorders and conditions of clinical concern, and as such, it provides good utility in the assessment of many adult college students.

While neither specifically tapping ADHD symptom criteria nor that of another psychological disorder per se, the 7-item ADHD Cognitions Scale (ACS) developed by Knouse et al. (2019) taps potentially dysfunctional ADHD-related automatic thoughts, such as "I'll just do this one thing first," which have been found to correlate with ADHD symptoms. Items on the ACS are rated on a 5-point Likert-type scale from 1 (*not at all*) to 5 (*all the time*) based on how often thoughts occur. In the development of the ASC, scores were found to be significantly higher in those with self-reported *DSM-5-TR* symptoms of ADHD at or above a clinical threshold (i.e., a proxy diagnosis). Along with ADHD symptoms, ACS scores have also been found to be positively correlated with domain-specific functional impairment as measured by the Weiss Functional Impairment Rating Scale (WFIRS; Weiss, 2000) and EF difficulties in daily life (Knouse et al., 2019). This measure may be particularly useful given the proposed connection between overly positive or permission-giving thoughts regarding ADHD symptoms and avoidance behaviors (Knouse & Mitchell, 2015, as cited in Knouse et al., 2019), and in cases where progress to psychotherapy may provide useful guidance in structuring cognitively focused intervention.

19.1.3 Measures of ADHD-Related Impairment

In order to meet *DSM-5-TR* criteria for ADHD, there must be evidence of impairment in which symptoms either interfere with or reduce the quality of an individual's functioning in the social, academic, or occupational domain (APA, 2022). Thus, measures of functional impairment as a component of an ADHD assessment battery are essential. Further, the perspective of the client (i.e., the self-report) is logically critical in establishing maladjustment, especially considering that some aspects (e.g., failure to attend appointments) may not be readily apparent to other informants (e.g., parents) in an adult assessment.

One measure of domain-specific impairment that can be related to ADHD is the Weiss Functional Impairment Rating Scale (WFIRS; Weiss, 2000), with items rated on a 4-point scale from 0 (*never or not at all*) to 3 (*very often or very much*; Canu et al., 2020). The WFIRS is available in self- and informant-report forms and assesses perceived impairment in 7 areas of functioning, including family (8 items), work (11), school (11), life skills (12), self-concept (5), social (9), and risk (14). One downside of the WFIRS is that norms are not provided; however, scores can be calculated by either summing all item ratings or finding the average of all item ratings for each domain, and, according to Weiss (2000), any domain with at least two items scored 2, one item scored 3, or a mean score of >1.5 can be considered in the impaired range. It is of note, though, that impairment indicated on this self-report (and any others, unless specifically noted) may not be uniquely caused by ADHD symptoms (Canu et al., 2020), and some of the items on the measure directly tap internalizing symptoms, including those related to mood and anxiety (Fuermaier et al., 2018), so clinicians are urged to follow-up in assessments to more concretely tie ADHD to dysfunction (and to rule out other possible causes). One of the primary benefits of using the WFIRS self-report is that the information it provides may help clinicians improve the efficiency of intervention planning by targeting domains of functional impairment (Haugan et al., 2021).

A further benefit of using the WFIRS in the assessment of functional impairment is its utility across a broad range of potential clients. It has been adapted into a number of languages and has strong cross-cultural validation (Canadian ADHD Resource Alliance [CADDRA], 2021; Dose et al., 2019). Additionally, the self-report version has been validated for use across adolescence and adulthood, despite being initially developed for use in children (CADDRA, 2021; Canu et al., 2020; Sasser et al., 2017), with high internal consistency across the board. Finally, during treatment, the WFIRS (and, for that matter, other measures of impairment) can serve as a valuable means of measuring functional changes across time, aiding in treatment planning and the assessment of intervention effectiveness (CADDRA, 2021; Canu et al., 2020; Sasser et al., 2017).

Another option for assessing impairment is the 23-item Barkley Functional Impairment Scale for Adults (BFIS; Barkley, 2011c; Ramsay, 2015). The BFIS provides adult norms and is available in both self- and informant-report forms (a parent-report form for children and adolescents is also available; Barkley, 2016). Items are rated on a 10-point scale of severity from 0 (*not at all*) to 9 (*severe*) regarding difficulties in 15 different life domains during the past 6 months (McGill, 2014). The domains include Home/Family, Home Chores, Work, Social Strangers, Social Friends, Community Activities, Education, Marriage/Cohabitating/Dating, Money Management, Sexual Relations, Driving, Daily Responsibilities, Self-Care Routines, Self-Maintenance, and Child Rearing (Ramsay, 2015). It is of note, though, that research on this adult version of the BFIS is relatively scant (Lewandowski et al., 2016).

19.1.4 Measures of Executive Functioning

It has been well established that adults with ADHD struggle with executive functions (EFs), including organization, planning, initiating and completing tasks, tracking and shifting between tasks, self-monitoring, and inhibition (Boonstra et al., 2005; Solanto, 2015; Zhang et al., 2021). Although not included in the *DSM-5-TR* diagnostic criteria for the disorder (APA, 2022), assessing for EF-related difficulties as part of a psychological evaluation for ADHD can provide a valuable indicator of frequently experienced ADHD-related symptoms (Solanto, 2015). Additionally, research suggests that EF deficits are related to lower quality of life (QoL) and worse interpersonal relationships, life outlook, life productivity, and relationships (Zhang et al., 2021). Therefore, such EF concerns can serve as a helpful diagnostic indicator and help clinicians conceptualize presenting symptoms and current functioning (Ramsay, 2015).

A frequently utilized EF self-report measure is the 89-item Barkley Deficits in Executive Functioning Scale (BDEFS; Barkley, 2011b), on which items are rated on a four-point scale of severity from *never or rarely* (1) to *very often* (4; Delhi et al., 2013; Ramsay, 2015). This norm-based inventory assesses EF across five subscales/domains: (a) self-regulation of time; (b) self-organization/problem-solving; (c) self-motivation; (d) self-restraint; and (e) self-regulation of emotions. The BDEFS provides total scores for each domain and total EF and ADHD-EF Index scores. Research findings suggest the BDEFS has utility when assessing for ADHD, as it was found to be substantially related to symptoms of IA and HI (Barkley, 2015; Delhi et al., 2013). Additionally, strong correlations have been noted between almost all domains of impairment on the BDEFS and IA symptoms (Dehili et al., 2013).

Another common EF measure is the Brown Executive Function/Attention Scales (Brown EF/A), which are available in parent-, teacher-, and self-report forms and contain between 56 and 58 items depending on the version (Pearson, 2019). The adult self-report form has been in use since 1996 (originally as the Brown Scales for Adolescents and Adults [Brown, 1996], revised and renamed the Brown EF/A Scales in 2018), meant for use by adults age 19 and older (Brown Clinic for Attention & Related Disorders, 2022). The Brown EF/A Scales are organized into six clusters of EF (i.e., Activation, Focus, Effort, Emotion, Memory, and Action, based on Brown's model of EF), with items tapping the severity of certain problems rather than frequency. Additionally, this measure contains context-specific items (e.g., difficulty remembering what has been read when reading is assigned, not self-selected text), *DSM-5-TR* symptoms of ADHD, and other aspects of EF impairments not included in the diagnostic criteria for the disorder. The Brown EF/A Scales offer combined-sex and separate-sex norms across forms and age ranges (Pearson, 2019).

The 80-item Behavior Rating Inventory of Executive Function, Adult Version (BRIEF-A) is a detailed measure that is available for use with individuals ages 18–90 in both self- and informant-report forms (Ramsay, 2015; Roth et al., 2005). Items are rated on a three-point scale (i.e., *never, sometimes, often*), and the measure yields nine subscale scores: Inhibit, Shift, Emotional Control, Self-Monitor, Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials. These subscales are organized into two indices: the Behavioral Regulation Index (BRI; i.e., ability to maintain appropriate regulatory control of one's behavior and emotional responses) and the Metacognition Index (MI; i.e., ability to systematically solve problems via planning and organization while sustaining task-completion efforts in active working memory). There is also an overall summary score, the Global Executive Composite (GEC), which contains all nine subscales on the measure. Results from the BRIEF-A utilize normative data to provide *T*-scores ($M = 50$, $SD = 10$), with 65 or higher considered clinically significant/elevated.

Other EF measures available for use with young adults include the 100-item Comprehensive Executive Function Inventory (CEFI; Naglieri & Das, 1997; Naglieri & Goldstein, 2013; Fenwick & McCrimmon, 2015) and the adapted, 10-item version of the Amsterdam Executive Function Inventory (AEFI; Baars et al., 2015). The CEFI is a norm-referenced measure of EF that is typically utilized with children and adolescents but can also be used with 18-year-olds. It taps strengths and weaknesses related to various domains of EF (Naglieri & Goldstein, 2013; Fenwick & McCrimmon, 2015). Items are rated on a six-point scale (i.e., *Never, Rarely, Sometimes, Often, Very Often, Always*) based on behaviors during the past 4 weeks and are organized. Nine EF domain scales (with 9–12 items each) are scored, including Attention, Emotion Regulation, Flexibility, Organization, Planning, Self-Monitoring, Initiating, Working Memory, and Inhibitory Control. The CEFI is normed and provides standard scores, percentile ranks, and classifications for each of the nine subscales and an overall Full Scale score (Naglieri & Goldstein, 2013; Fenwick & McCrimmon, 2015).

The adapted, slightly briefer AEFI for use with 17-to-20-year olds was modified from the original AEFI version for adolescents (Baars et al., 2015). Items are rated on a three-point Likert scale (i.e., *not true*, *partly true, true*) and are organized into three subscales measuring aspects of EF (i.e., attention, planning, self-control, and self-monitoring). The adapted AEFI demonstrates even better reliability than the original on each of the three subscales, bolstering its viability as a brief EF measure (Baars et al., 2015).

19.1.5 An Additional Facet for Assessment: Quality of Life

Historically, there has been relatively little focus on quality of life (QoL) in psychology and psychiatry, and research that has examined it often fails to define the construct. Generally speaking, QoL is defined by the World Health Organization (The WHOQOL Group, 2008) as a concept that relies on subjective, individual perceptions of both positive and negative aspects of life as the individual lives it. It can include evaluations of one's health, job, cultural context, neighborhood, and even spirituality. QoL does not align neatly with physical health but does have a high correlation with certain functional and psychosocial impairments and may serve as a third variable that is influenced by ADHD symptoms but in turn increases perceived impairment (in the case of low QoL; Brod et al., 2005; Gjervan & Nordahl, 2010). Quality of life assessments can also facilitate ways for clinicians to encourage their clients to follow through with post-assessment recommendations, including psychological or pharmaceutical interventions. Assessing QoL can also help clinicians develop more holistic case conceptualizations and treatment plans (Brod et al., 2005; Gjervan & Nordahl, 2010; Suhr et al., 2017).

Further, research supports the association between ADHD, EF difficulties, and quality of life (QoL) in that adults with ADHD have significantly worse QoL, especially those that also have comorbid conditions like depression or anxiety (Zhang et al., 2021). Given the likelihood of significant life impacts beyond just the experience of ADHD-related symptoms and strictly defined "impairment," assessing and monitoring QoL could be an important component of psychological evaluation and treatment-outcome monitoring when ADHD is a presenting concern.

An inventory that taps QOL and that was designed with ADHD in mind is the 29-item self-report Adult ADHD Quality of Life Questionnaire (AAQoL; Gjervan & Nordahl, 2010), for which items are rated on a 5-point Likert-type scale from 1 (*not at all/never*) to 5 (*extremely/very often*). The AAQoL provides an overall score as well as four subscale scores for various life domains, including life productivity (11 items), psychological health (6), life outlook (7), and relationships (5), with higher scores indicating a higher perceived quality of life (Brod et al., 2006; Gjervan & Nordahl, 2010; Matza et al., 2007; Ramsay, 2015). Its earliest iterations only included three domains of life (productivity, relationships, and health); Life Outlook was added, and Health was reoriented to focus on psychological health in the latest version (Brod et al., 2005, 2006; Matza et al., 2011).

With regard to these various domains in which quality of life is indexed with the AAQoL, Life Productivity is considered the ability to accomplish tasks. QoL in this domain may be affected by procrastination, memory difficulties, poor organization, time management, and planning (OTMP) skills, and similar deficits (Brod et al., 2005). Similarly, the Relationships domain consists of the ability to maintain social relationships with others across a range of settings and dynamics. This area of QoL may be impacted by difficulty remaining "present" during interactions, speaking before thinking, and engaging in behavior that may be perceived by others as rude and impulsive. The Psychological Health domain is conceptualized to capture primarily psychological health, which may be affected by fatigue, low self-esteem, or depression symptoms. Life Outlook describes the positivity and value an individual ascribes to their experiences. While it is a broader domain than the other three, however, it captures a critical piece of an individual's QoL. It may be negatively affected by anhedonia, feeling unable to manage, or procrastination on tasks (Brod et al., 2006; Gjervan & Nordahl, 2010; Matza et al., 2007).

The AAQoL may also help clinicians better understand the role protective factors could play in an individual's QoL. Brod et al. (2005) note that some of these factors can include access to coaching (especially for ADL impairments), exercise, open communication in relationships, the ability to avoid professional roles that necessitate managing details or maintaining meticulous organization systems, having fewer severe symptoms or comorbidities, and the use of pharmacotherapy. The AAQoL's severity of symptoms indicators can provide deeper insight into not only the broad functional status of an individual but more detailed aspects of their functional status, such as the ways in which specific types of relationships (romantic, professional, peer, etc.) may be impaired (Gjervan & Nordahl, 2010).

While we recommend the AAQoL for QoL assessment in instances where ADHD is the predominant presenting concern (or research focus), as it remains the single QoL measure specifically constructed with ADHD in mind, other QoL measures exist that are more broadly conceived. One example of these that is relevant is the World Health Organization Quality of Life Assessment (WHOQOL; The WHOQOL Group, 1998). The WHOQOL is accessible in a brief form with 26 items that tap the QoL domains of physical health, psychological health, social relationships, and environmental factors (Bonomi et al., 2000; Unstun et al., 2017). The WHOQOL has been shown to be sensitive to the impact of ADHD on QoL in adulthood in community samples (Combs et al., 2014).

19.2 Reliability of Self-Report Measures for Adult ADHD

Perhaps it is an understatement to say that reliability is of significant concern when utilizing self-report measures. Accuracy of an adult client's recall regarding childhood symptoms and age of onset, over- or under-reporting of symptoms or impairments, and disagreement between self- and informant-reports are factors that clinicians must take into consideration when developing an assessment plan for possible adult ADHD (Barkley et al., 2011; Ramsay, 2015; Rucklidge et al., 2002; Sibley et al., 2012). For these reasons, the literature on self-reports consistently suggests that they should not be the only means used to assess an individual for a clinical ADHD diagnosis, but rather it should be used as a screener, to supplement clinical interviews and other informant reports, as part of a more comprehensive battery of assessments (Brod et al., 2006; Fuller-Killgore et al., 2012; Kooij et al., 2008; Ramsay, 2015; Rösler et al., 2006). Because the complexities of reliability issues around self-report measures of ADHD are tied to the psychometrics of each individual instrument, in this next section we will cover some of the most commonly used self-report measures for assessing symptoms, impairment, and quality of life. We only review measures that tend to have ample data. Despite their shortcomings, these measures have a place in practice and research.

19.2.1 ASRS

ASRS reliability data are somewhat mixed across the literature, but it has typically been found to be robust, falling in the good-or-better range (Fuller-Killgore et al., 2012), including when examining correspondence between self- and clinician ratings (Biederman et al., 2020). In addition, a number of studies have found that the measure also demonstrates short-term (same day) test-retest reliability in most demographic groups defined by age, sex, cognitive ability, and academic achievement (Biederman et al., 2020; Fuller-Killgore et al., 2012; Lovett et al., 2021; Somma et al., 2021). In college students and general adult populations, the ASRS has high internal consistency ($a = 0.84–0.94$; Fuller-Killgore et al., 2012; Silverstein et al., 2018). In one study focusing on adolescents, its internal consistency was excellent across both gender and age ($\alpha > 0.90$; Adler et al., 2012). However, some data suggests that this cross-demographic reliability may not hold true for all groups. For instance, 6-week test-retest reliability was only acceptable ($r = 0.69$) in a college student population, a demographic for whom the ASRS was not specifically designed, when examined in a sample of individuals with and without ADHD diagnoses (Lovett et al., 2021). In the same study, 19% of participants' scores significantly changed their diagnostic status in the 6-week interval between administrations. Still, clinical research data supports the use of the ASRS as a test-retest measure for assessing response to treatment in individuals with a clinical diagnosis of ADHD and relatively stable pre-treatment symptom presentations (Biederman et al., 2020; Matza et al., 2011). This parallels other conclusions that the ASRS has high reliability in clinical samples but significantly less so in non-clinical samples (Lovett et al., 2021; Matza et al., 2011).

The abbreviated version, the ASRS-S, also has a body of literature supporting its clinical value. Fuller-Killgore et al. (2012) note that because the screener has only six questions, internal consistency is inherently lower ($\alpha = 0.67$) than the full ASRS measure and that it is sometimes used inappropriately as a diagnostic tool rather than as intended—as an efficient means of evaluating the need for further assessment. When used appropriately as a screener, the ASRS-S's reliability is more than adequate (Green et al., 2019; Somma et al., 2021).

While both the 18- and 6-question forms of the ASRS are widely used as diagnostic tools, it is unsurprising that evidence suggests they are best used as only one part of a more comprehensive diagnostic process (Biederman et al., 2020; Fuller-Killgore et al., 2012; Lovett et al., 2021). In part, this is because the ASRS is a measure that has excellent reliability under fairly specific conditions—in clinical samples of individuals with ADHD diagnoses and stable symptoms. In practice, however, it becomes clear that the ASRS 18-item and screener measures may be most effectively used in conjunction with more detailed self-reports like the Conners' Adult ADHD Rating Scales (CAARS; Conners et al., 1999) and even more comprehensive measures (Fuller-Killgore et al., 2012; Lovett et al., 2021; Silverstein et al., 2018).

19.2.2 CAARS

The CAARS has high test-retest reliability across all its clusters (most results indicate $r > 0.77$; Ben-Sheetrit et al., 2019; Fuller-Killgore et al., 2012; Kooij et al., 2008). In addition, internal consistency of the total score is excellent in both college student and general adult populations ($a = 0.97$ and 0.95, respectively; Fuller-Killgore et al., 2012; Kooij et al., 2008). Mitchell et al. (2009) indicate that the individual subscales of the CAARS have somewhat lower rates of internal consistency in college students (inattentive, $\alpha = 0.84$; hyperactive-impulsive, $\alpha = 0.74$), however these are still in acceptable ranges. Items that capture *DSM* inattention symptoms are, as might be expected in adults, the most predictive of an ADHD diagnosis (Ben-Sheetrit et al., 2019; Fuller-Killgore et al., 2012; Kooij et al., 2008). In addition, research supports the combined use of just the CAARS Clusters B (Hyperactivity/Restlessness) and E (*DSM-IV* Inattention Symptoms) subscales as a highly reliable brief ADHD screener in college students. It is important to note, however, that other findings suggest that *DSM* ADHD symptom endorsements are higher in college students when those symptoms are listed alongside other, non-*DSM* ADHD symptoms (e.g., executive functioning problems). In contrast, Mitchell et al. (2009) found that including non-ADHD symptoms (e.g., depression symptoms) in an adapted version of the CAARS resulted in lower *DSM* ADHD symptom endorsement in college students. This serves as a reminder that, as with all self-report assessments, the CAARS is best used as an *indicator* of potential clinically elevated ADHD symptoms, which should be corroborated by other measures for an official diagnosis of ADHD or any other disorder.

19.2.3 WURS

The Wender Utah Rating Scale (WURS) is a retrospective symptom checklist assessing childhood ADHD symptoms. The abbreviated WURS-25 has a sensitivity of 86% and a specificity of 99% for identifying individuals with a history of ADHD at its suggested cutoff score (Ward et al., 1993). One systematic review found that its internal consistency is typically good to excellent ($a = 0.86$–0.92; Taylor et al., 2011). In college students, the test-retest reliability of the WURS is strong at both 1 week and 2 months (in most studies, $r > 0.80$; Fossati et al., 2001; Öncü et al., 2005; Taylor et al., 2011; Wierzbicki, 2005), and it is not significantly vulnerable to emotional states or the transitory events that may be of concern when working with young adults (Fossati et al., 2001; Wierzbicki, 2005). However, Fossati et al. (2001) found that, in retest administrations, individuals consistently endorsed fewer childhood ADHD symptoms than in initial administrations of the WURS.

This should be taken into consideration if the WURS is utilized as a measure of treatment outcome. In the general adult population, the reliability of the WURS appears to be high even over relatively long durations, which is meaningful in clinical assessment given the noted hurdles to obtaining accurate self-report of childhood symptoms (Barkley et al., 2011; Ramsay, 2015). For instance, Lundervold et al. (2021) found that test-retest reliability was high, with an average of 7 years (and up to 10 years) between administrations of the WURS. Further, in a systematic review, Taylor et al. (2011) found that, of 14 common measures, both the WURS-61 and the WURS-25 had good test-retest reliability ($r = 0.68, 0.74$). Additionally, there is some support for the cross-cultural test-retest reliability of the WURS in its translated iterations at one and 2 months (Fossati et al., 2001; Öncü et al., 2005; Retz-Junginger et al., 2003), and in such instances, reliability has been consistent across sex (Öncü et al., 2005; Wierzbicki, 2005).

19.2.4 BAARS-IV

Generally, research specifically focusing on the psychometrics of the BAARS-IV appears to be sparse, with the exception of what is reported in the administration manual (Barkley, 2011a). Barkley notes that test-retest total scores were not statistically different over an interval of 2 to 3 weeks. However, reporters did tend to nominate small increases in their recalled childhood inattention symptom endorsements and total ADHD score at the second administration. However, Barkley indicates that the clinical significance of this difference is inconsequential (Barkley, 2011a, p. 54).

In addition, Barkley (2011a) notes the adequate results of a test-retest assessment of the BAARS-IV in which both Current and Childhood Symptoms scales were administered at T1 and T2 (2–3 week intervals; reliability of the subscales ranged from $r = 0.66$–0.88). The internal consistency of the subscales within the BAARS-IV is also adequate (Current ADHD Inattention, $\alpha = 0.90$; Current ADHD Hyperactivity, $\alpha = 0.78$; Current ADHD Impulsivity, $\alpha = 0.81$; Current ADHD total score, $\alpha = 0.91$; Childhood ADHD Inattention, $\alpha = 0.94$; Childhood ADHD Hyperactivity-Impulsivity, $\alpha = 0.91$; Childhood ADHD total score, $\alpha = 0.95$).

Barkley (2011a) makes special mention of data that is derived by the BAARS age of onset item. He writes that this, specifically, should be used with caution. While it does represent a starting point for discovering the onset of ADHD symptoms in any case, the reliability of an adult's retrospective self-report of this particular detail can be problematic (Barkley et al., 2011; Ramsay, 2015; Rucklidge et al., 2002; Sibley et al., 2012). Interestingly, older adults provide age of onset responses that better align with those from other informants (e.g., parents; Barkley et al., 2011).

19.2.5 BADDS

The BADDS has strong internal consistency ($\alpha > 0.90$; Fuller-Killgore et al., 2012; Kakubo et al., 2018), and it correlates highly with other measures assessing ADHD symptoms, like the CAARS and ASRS (Fuller-Killgore et al., 2012; Rösler et al., 2006). In addition, it has excellent 2-week test-retest reliability (Rucklidge et al., 2002).

It may interest the reader to note that an adaptation of the BADDS for adolescents exists. However, when it was administered to a clinical sample of adolescents, Rucklidge et al. (2002) found that a rather large percentage (46.7%) of individuals who did not meet the cutoff for ADHD on the BADDS were actually false negatives (by prior diagnosis). Such issues with validity suggest that the BADDS is best used in the adult populations for which it was designed. Rucklidge also notes that because the BADDS assesses symptoms that fall outside the *DSM*'s ADHD diagnostic criteria, it should be considered carefully within the context of a more thorough diagnostic evaluation (Rucklidge et al., 2002). However, there is also evidence supporting the use of the BADDS in cross-cultural contexts as well as in cases of ADHD with comorbidity (Kakubo et al., 2018).

19.2.6 WFIRS

In a study using a sample of college students, the internal consistency of the self-report WFIRS was found to be excellent ($a = 0.96$), with the subscales' consistency falling in the good to excellent range ($a = 0.85$–0.94; Canu et al., 2020). In a Persian adaptation of the WFIRS administered to a non-indicated sample of Iranian adolescents, internal consistency across the functional domains and the total score, as well as the test-retest reliability of the total scale, were high (domains: $a = 0.72$–$0.0.92$, total score: $a = 0.94$, $r = 0.80$; Hadianfard et al., 2019). A study utilizing a clinical sample of Norwegian adolescents found that, in line with the other literature, internal consistency was good ($a > 0.79$; Haugan et al., 2021). In addition, correlations between the individual domains and the total score on the WFIRS were strong ($r = 0.63$–0.81), while correlations between the domains varied in the moderate-to-high range ($r = 0.31$–0.70). Further, Canu et al. (2020) found the WFIRS to have good concurrent validity and cross-informant agreement (parent-child) in a large sample of college students.

19.2.7 BFIS

The internal consistency of the BFIS is high ($a = 0.97$). However, its test-retest correlations are less impressive ($r = 0.40$–0.72), with a test-retest $r = 0.71$ for its Mean Impairment Score across 2 to 3 weeks (Barkley, 2016). Additionally, test-retest data show small but significant decreases in the Mean Impairment Score as well as across scores in three domains (Social Relations with Strangers/Acquaintances, Social Relations with Friends, and Marriage/Cohabiting/Dating; Barkley, 2016). While such data do indicate that the BFIS is a reliable measure for identifying functional deficits in individuals with ADHD and other disorders, it is still suggested that the BFIS would best be used alongside other measures to develop a more comprehensive conceptualization of an individual's impairments and symptoms (Barkley, 2016; Lewandowski et al., 2016; Sasser et al., 2017).

19.2.8 AAQoL

Test-retest reliability of the AAQoL is good at 2 weeks, considering all four domains (ICCs: Psychological Health $r = 0.83$; Life Productivity $= 0.88$; Life Outlook $= 0.79$; Relationships $= 0.75$) as well as the overall score (ICC $= 0.93$; Brod et al., 2006; Matza et al., 2011). This appears to remain true even when administered several times across a period of 4 months (Matza et al., 2011). However, the AAQoL is most effective at assessing QoL and potential domains of concern in symptom-stable clinical populations (Matza et al., 2007, 2011). The AAQoL's results tend to closely match reports from clinicians as well as results from other assessments (e.g., CAARS), and as such, it may be a convenient means of evaluating and tracking individuals' responses to interventions over time, at least with regard to positive adjustment (Brod et al., 2006; Gjervan & Nordahl, 2010).

It is perhaps of interest that ADHD-symptomatic adults who were either un- or misdiagnosed in childhood tend to report worse adjustment on the AAQoL than adults with an appropriate, pre-existing diagnosis of ADHD (Brod et al., 2005; Matza et al., 2011). This may be an accurate self-assessment, wherein those without a proper diagnosis in childhood presumably received less support over time and may have been unfairly labeled (e.g., "lazy," "stupid," "hopeless"). Regardless, this might be taken into account in the interpretation of AAQoL scores and suggests follow-up with an adult client presenting for an initial ADHD evaluation to ensure the accuracy of the QoL assessment.

19.3 A Word of Caution: Malingering

As noted earlier, one of the salient concerns in assessment, and perhaps particularly so with adult clients, is the possibility of malingering. Malingering involves the intentional overreporting of symptoms and impairment to deceive the mental health professional and effect a false-positive diagnosis of ADHD. One of the inherent vulnerabilities of self-report measures is that responses can easily be consciously manipulated to portray greater pathology and maladjustment. This has, in fact, been empirically demonstrated in the case of ADHD; for instance, Young and Gross (2011) assigned non-diagnosed college students to two groups, one instructed to give their best effort on assessment measures, and another instructed to try to feign having ADHD, given the benefits (e.g., accommodations, medication) of doing so and that blatant overendorsement would be detectable (i.e., why and how to malinger). Responses from these groups on both child and current ADHD symptom self-reports were compared to those of a college-student ADHD group identified via clinical chart review. Findings were that the clinical and feigned-ADHD groups *did not* differ on ADHD symptom reports, but both were clearly differentiated from the best-effort control group. Bryant et al. (2018) very nearly replicated such findings, focusing instead on a measure of psychosocial impairment (vs. a symptom report). Such findings suggest that it is not "rocket science" for intentional adults to fake clinically concerning symptoms and impairment in an assessment of ADHD.

There are, as noted previously, long-documented reasons that incentivize such intentional faking of ADHD: acquiring academic accommodations that are perceived as desirable, prescription medication for instrumental or recreational use (or diversion), and other disability benefits, among others (Advokat et al., 2008; Hartung et al., 2013; Lefler et al., 2021; Lovett & Harrison, 2021; Rabiner et al., 2009; Tucha et al., 2015); Unsurprisingly, there is evidence suggesting that not an insubstantial minority of adults (estimates ranging to 48% of self-referred college students) make non-credible responses in ADHD assessment (Harrison et al., 2010; Harrison & Edwards, 2010; Nelson & Lovett, 2019; Suhr et al., 2008; Sullivan et al., 2007). As responses on self-reports are entirely determined by the client (or participant) themselves, they are intrinsically and especially vulnerable to deceptive responses.

Putting aside the fact that such intentional deception on the part of a client is rarely, if ever, something that a clinician or researcher is directly responsible for, it *is* still their responsibility to prevent false-positive diagnoses to the extent that is possible. There is no surefire means of detecting malingering, and this is especially the case if self-reported ADHD symptoms and impairment constitute all measures (as they do in many research designs). Screening for inconsistent responses may serve as one safeguarding check in such instances. Upon scrutiny, many self-report measures may have items that are either essentially repetitive in nature (e.g., "lose things frequently" and "trouble finding schoolwork materials when needed") or should closely align with each other (e.g., "has trouble waiting their turn" and "blurts out answers before questions have been completed"); responses to such dyadic items that are frequently inconsistent (i.e., one response is not close to the other) flag potential nonvalid responses that could then be probed further by the clinician. Some self-report measures, such as the CAARS, as noted above, feature established inconsistency indices, which may add a level of protection. Attention check items (e.g., "I was born on February 30th"; Beach, 1989) might be inserted into online or paper-based survey batteries, and these might help weed out nonvalid responses that are random or have a positive or negative bias. However, support for the utility of such items, especially with regard to the quality of data obtained, is equivocal (Hauser & Schwarz, 2015; Shamon & Berning, 2021).

While clinical intuition (e.g., "Spidey sense") and analysis (e.g., scrutiny of client's responses across self-report measures) may sometimes do the trick, more robust measures are really needed to better signal potential malingering in ADHD assessment from an empirical standpoint. This gets back to the important note: When diagnosis really matters (e.g., for potential clinical intervention or determination of accommodations), the gold-standard approach of assessment that includes self-reports as part of a battery of measures (including from other qualified informants) is really indicated. It would be erroneous to imply, however, that malingering is not an issue to be taken lightly in research studies that do not have such high stakes (see an instance in Hoelzle et al., 2019). Wallace et al.'s (2019) meta-analysis of published means of malingering detection in the ADHD literature suggests that symptom validity tests of the sort mentioned above, like the CAARS Infrequency Index and the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Butcher et al., 2001), validity scales that detect irregular or exaggerated item response patterns, do have some utility. Better, however, were *performance validity* tests, such as the Test of Memory Malingering (TOMM; Tombaugh, 1996), a cognitive test that has established norms for excessively irregular or impaired performance. Finally, while it is beyond the scope of this paper to fully review the literature with regard to such robust methods of detection of malingering, we encourage practitioners and researchers alike to recognize the risk of malingering or other invalid responses in their methods and to take some concrete steps to control for it. Further constructive reading is available on this matter (e.g., see issue including Lovett & Harrison, 2021).

19.4 Conclusion

There is a wide array of self-report instruments that assess various aspects of symptom presentation and adjustment that can be useful in the assessment of ADHD in adults. Even a cursory examination of the research literature confirms that these are almost ubiquitously part of study procedures when adult ADHD is being considered. While there are limitations with regard to potential malingering and inconsistency across informants (see discussion in Sibley et al., 2012) that are real, it is *always* necessary to tap the client's or participant's impression of their own behaviors in an assessment of adult ADHD, and the screeners and broader measures that are discussed herein represent reasonable and efficient options. As long as the psychologist or other mental or health care provider keeps the limitations and potential pitfalls in mind, we feel that they will obtain necessary and important data by employing them.

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20 Social Relationships of Individuals with ADHD Across the Lifespan

Judith Wiener

One of the criteria for diagnosis of Attention-Deficit Hyperactivity Disorder (ADHD) stipulated in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5-TR; American Psychiatric Association, 2022) is that ADHD symptoms interfere with or reduce the quality of academic, occupational, or social functioning. As will be described below, a high proportion of children, adolescents, and adults with ADHD experience social impairment, and the most debilitating part of that impairment is challenges with social relationships. Understanding and treating their social relationship problems is important because they are associated with negative outcomes, including mental health challenges (Becker et al., 2012; Humphreys et al., 2013; Meza et al., 2016; Simmons & Antshel., 2021), low academic performance and attainment (Dupaul & Langberg, 2015), low occupational status (Barkley, 2015), and unstable relationships with intimate partners (Wymbs, 2021).

The purpose of this chapter is to review research that describes the social relationships of individuals with ADHD across the lifespan. I use Bukowski and Adam's (2005) framework for researching peer relations and developmental psychopathology as a guide for this chapter. They proposed that research establish the markers, mediators, moderators, mechanisms, and meanings of peer relationship difficulties among individuals with various types of psychopathology. I begin by summarizing the findings from studies that show that children, adolescents, and adults with ADHD have more difficulty with aspects of peer relationships than their typically developing peers (i.e., markers). Although family relationships of children and adolescents with ADHD are important (see Johnston et al., 2012; Johnston & Chronis-Tuscano, 2015; Wiener, 2020 for reviews), a description of the extensive research on this topic is beyond the scope of this chapter. I then examine variables that are associated with their peer relationships, including social skills, social cognition, emotion dysregulation (ED), and contextual factors. When the research is clear, I indicate whether these variables are moderators, mediators, or mechanisms. In the next section, I review studies examining the meaning of social relationship difficulties for individuals with ADHD. I describe research on their self-concept, attributions for their social difficulties, and loneliness as well as summarize the results of three qualitative studies that assess the subjective experience of children, adolescents, and adults with ADHD with regard to social relationships. (At the beginning of each section of this chapter, I include quotations from

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the participants in these studies and another qualitative study evaluating an intervention.) The final section provides an overview of interventions in the social domain.

20.1 What Is the Nature of the Social Relationship Difficulties of Individuals with ADHD?

In a meta-analysis conducted by Ros and Graziano (2018), the effect size for the relationship between peer relationships and ADHD symptoms or diagnosis was moderate. Although the problems with social relationships of individuals with ADHD occur across the lifespan, the nature of these difficulties and the research describing them vary with development. Research on children with ADHD has focused on peer status (the extent to which they are accepted or rejected by classmates), the nature of their friendships, and bullying. Studies with samples of adolescents and emerging adults with ADHD describe their friendships, bullying, and romantic relationships. In adulthood, researchers have investigated the nature of their relationships with intimate partners or co-workers.

20.1.1 Peer Status

> *They all use me... for my games and stuff. So I just stay here and wait for someone to come over, "Can I play your play station?" Fine, use it! All I want is someone to just play with at least... I don't care...* (Shea & Wiener, 2003, p. 68; male, age 11–13)

Peer status refers to the extent to which children are accepted or rejected by groups of peers with whom they frequently associate, such as classmates. It is important because longitudinal studies have shown that children who are rejected by peers are more likely to continue to have social difficulties and mental health challenges in adolescence and adulthood (Bukowski & Adams, 2005; Parker & Asher, 1987). Peer status is typically assessed using sociometric procedures. Children who spend considerable time together in a specific setting, such as a classroom or summer treatment program, are given a list of all of the other children in that setting. They are asked to rate the extent to which they like to play with the other children or to nominate the children they like most and least. Sociometric measures inform researchers about whether a child has an average number of like most and like least nominations, is popular (has a high number of like most nominations and few, if any, like least nominations), rejected (has a high number of like least nominations and few, if any, like most nominations), neglected (has fewer than the typical number of nominations), or controversial (has a high number of like most and like least nominations).

Sociometric studies conducted in elementary schools (Grygiel et al., 2018; Hoza et al., 2005a, b; Mrug et al., 2009; Stenseng et al., 2016), summer camps (Erhardt & Hinshaw, 1994; Hinshaw et al., 1997; Mikami & Mercer, 2017), and researcher organized play groups (Mikami et al., 2010a, b; Mikami & Lorenzi, 2011) showed that boys and girls with ADHD (ages 4–12) are less likely to be classified as popular or average and more likely to be rejected by their peers in comparison to children without ADHD. This rejection continues into adolescence (Bagwell et al., 2001; Sibley et al., 2010). Children with inattentive type ADHD are more likely to be neglected by peers, whereas children with a combined presentation are more likely to be rejected (Hodgens et al., 2000). Peer rejection of children with ADHD occurs shortly after they enter a specific setting (Erhardt & Hinshaw, 1994) and is typically stable (Hinshaw & Melnick, 1995; Mikami et al., 2015). In her review of the literature, Hoza (2007) indicated that between 50% and 80% of children with ADHD are rejected by their peers.

As reviewed by Barkley (2015), research conducted in the United States (Barkley et al. 2008; Biederman et al., 2008), Canada (Weiss & Hechtman, 1993), and Norway (Mordre et al., 2012; Torgersen et al., 2006) has shown that both adults with ADHD who were diagnosed as children and those who were diagnosed as adults have significant challenges in the workplace. Their occupational status is lower than that of comparison adults; they change jobs more frequently and are more likely to be fired or dismissed. In part, their lower occupational status may be associated with their lower academic attainment. Their challenges in the workplace, however, are also related to their inattentiveness and hyperactivity, challenges with executive functioning, and social difficulties. Specifically, adults with ADHD report that they have trouble getting along with others in their workplace (Barkley et al. 2008).

20.1.2 Friendship

> *I was into the idea of having friends, I was, but like, I told myself, if things aren't going to go well, be willing to be alone... to not bother with it because your're not gonna force people to like you, and you're not gonna force people to hang out with you.* (Maya Beristain & Wiener, 2020a, b, p. 287; female, age 16–18)

In contrast to peer status, which refers to acceptance or rejection by a group of children with whom one associates on a frequent basis, friendship is a mutually dyadic relationship. In addition to counting the number of friends an individual has, it is important to consider the extent to which the relationships are stable, the characteristics of the friends (e.g., age, gender, where they interact, and whether the friend has learning or behavior problems), and the quality of the relationship (Bagwell & Schmidt, 2011). As discussed below, children, adolescents, and adults with ADHD all have challenges in establishing and maintaining high-quality close friendships.

20.1.2.1 Children

When assessing children's friendships, researchers typically ask them to list their friends and answer several questions about each of them. If the study is done in a school setting, researchers often ask the students to confine their nominations to children in their classes and are then able to determine whether their friendship nominations are reciprocated. If the study is conducted in a clinical setting, parents and teachers are typically asked to name the friends of the participants to obtain corroboration of the children's nominations. Although reciprocal nominations are the gold standard in terms of determining whether the friendships are mutual, parent and teacher corroboration of child friendship nominations is a reasonable substitute because they are highly correlated with reciprocal nominations (Wiener & Schneider, 2002). In studies where parent nominations are used, the mutuality of relationships of friends not in the children's class can be determined.

Boys and girls with ADHD report that they have a similar number of friends as their counterparts without ADHD; their friendship nominations, however, are less often reciprocated or corroborated by parents or teachers (Blachman & Hinshaw, 2002; Hoza et al., 2005a, b; Kouvava & Antonopoulou, 2020; Lee et al., 2021; Marton et al., 2015). Furthermore, the friendships of children with ADHD are less likely to be stable across a school year (Lee et al., 2021) and are of shorter duration (Kouvava & Antonopoulou, 2020; Marton et al., 2015) than the friendships of their typically developing peers. Consistent with findings that children tend to befriend children who are similar to them in terms of personality and academic achievement (Bagwell & Schmidt, 2011), a higher proportion of the friends of children with ADHD have learning or behavior problems than do the friends of children without ADHD (Kouvava & Antonopoulou, 2020; Marton et al., 2015). Furthermore, when the friends of children with ADHD also have behavioral difficulties, the friendship quality of the dyad suffers (Normand et al., 2021).

The quality of friendship consists of both positive and negative features. The positive aspects are companionship (frequency of social interaction between friends), intimacy and disclosure, and mutual support. The negative aspects are high levels of conflict and difficulty in resolving conflicts and repairing relationships when conflicts occur (Bagwell & Schmidt, 2011). For children age 12 and under, companionship is especially important, whereas for adolescents and adults, intimacy and mutual support are the key features that friends value (Bagwell &

Schmidt, 2011). In addition to using self-, teacher-, and parent-reported questionnaires, friendship quality has been assessed by observing children interact with their closest friend while doing structured or unstructured play tasks (Normand et al., 2011).

Children with ADHD report that they have less face-to-face contact with their friends outside of the school environment (Marton et al., 2015), lower levels of social support from peers (Mastoras et al., 2018), and higher levels of conflict (Kouvava & Antonopoulou, 2020) than children without ADHD. Normand and his colleagues (2011) found that, compared to typically developing children, children with ADHD perceive fewer positive and more negative features in their relationships with their friends, and they are less satisfied with their friendships. Normand et al., compared the interactions of friendship dyads consisting of two children without ADHD and dyads consisting of at least one child with ADHD. When interacting with their closest friends, children with ADHD tend to dominate and make insensitive and self-centered proposals (Normand et al., 2011). Consequently, in those dyads, there are lower levels of cooperation and higher levels of conflict and negative emotions, such as frustration (Normand et al., 2017, 2019). When engaged in a task designed to elicit cooperation, children with ADHD and their friends have reciprocal positive affect and behavior. In contrast, when the task is competitive, friends reciprocate each other's aggressive, controlling, and rule-breaking behaviors (Norman et al., 2022). Friendships are more likely to be discontinued within 6 months when there are higher amounts of conflict in the interactions between children with ADHD and their closest friend in a competitive play task (Normand et al., 2013).

20.1.2.2 Adolescents and Adults

Studies of friendships among adolescents and adults with ADHD examined the number, duration, and characteristics of the friends, peer crowd affiliation, and friendship quality. Adolescents with and without ADHD do not differ in the number of friends they report they have, the duration of their friendships, and the frequency of their contact (phone, online, or face-to-face). Girls with ADHD, however, have fewer friendships corroborated by parents. Similar to younger children, adolescents with ADHD are more likely to have friends who are two or more years older or younger than them and more likely to have friends who have behavior problems than their typically developing peers (Maya Beristain & Wiener, 2020b). Girls with ADHD are especially at risk; fewer of their friendship nominations are corroborated by parents, and their best friend is less likely to be attending their school. Although both males and females with and without ADHD report that they interact with their friends online, only girls with ADHD indicate that they meet some of their friends through social media and that their interactions with these friends are exclusively online (Maya Beristain & Wiener, 2020b). Adolescents with ADHD are more likely than other adolescents to affiliate with a deviant peer group, and this affiliation is associated with heavy alcohol use and illicit drug use (Marshal et al., 2003).

Studies on the friendship quality of adolescents with ADHD mainly examined the extent to which they claimed that their relationships involved intimacy and mutual support. Adolescents believe that they have lower levels of social support from peers (Timmermanis and Wiener, 2011). Rokeach and Wiener (2020) found that younger adolescents (ages 13–15) with and without ADHD did not report difference in the extent to which they viewed their relationship with their closest friend as mutually supportive, whereas older adolescents with ADHD (ages 16–18) reported that their relationships with their closest friend were less supportive than did adolescents without ADHD. As suggested by Rokeach and Wiener, the differences that emerged in older adolescents might be because they value mutual support and intimacy, and adolescents with ADHD find it harder to engage with friends at that level. Younger adolescents may still regard companionship (which was not measured in this study) as the key feature of a friendship. Adolescents with and without ADHD did not differ in terms of their reports of negative interactions within their closest friendships.

Graduation from secondary school is a time of transition that has an impact on friendships (Bagwell & Schmidt, 2011). Compared to students with low levels of self-reported ADHD symptoms, college students with high levels of self-reported ADHD symptoms are more often friends with students who also have high levels of ADHD symptoms (Mckee,, 2017). Among university students, higher self-reported ADHD symptoms are associated with more social interactions with friends on Facebook and more negative interactions with these friends (Khalis & Mikami, 2018). Adults with and without ADHD in Britain (age 27), however, did not differ in their reports of satisfaction with their friendships (Moyá et al., 2014).

20.1.3 Bullying

> *Well, this one was like, with one guy, kind of like a large person, around the stomach and stuff. And he's just so used to like bugging me, and he used to push me into my locker and stuff, and in retaliation I usually just said like, "Watch where you're going! and stuff. So then, he'd turn around and he'd shove me again and then I'd curse at him and then he'd turn around and say, "What did you say?". And then we start like, having a verbal fight.* (Shea & Wiener, 2003, p. 72; boy age 11–13)

Olweus (1993) defined bullying as chronic victimization by peers. It involves the perpetrator of bullying engaging in physical aggression, verbal aggression, or relational aggression against the victim of bullying. By definition, bullying involves an imbalance of power, with the perpetrator being more powerful than the victim. Individuals who are involved in bullying are classified as bullies (or perpetrators of bullying), victims (or victims of bullying), and bully-victims (or perpetrators-victims). Child and adolescent perpetrators of bullying are at high risk of engaging in intimate partner violence, child abuse, and workplace harassment in adulthood. Children and adolescents who are victims of bullying are at risk for intimate partner violence in adulthood and current and future mental health problems, including anxiety, depression, and self-harm (Pepler et al., 2008). Specifically, among young adults with ADHD, childhood peer rejection and victimization predict young adult self-harm, including nonsuicidal self-injury, suicidal ideation, and suicide attempts (Meza et al., 2016). Cyberbullying involves an intentional act to harm or embarrass another person using the Internet (e.g., social media) or text messages (Heiman et al., 2015). It is an especially pernicious form of bullying because the harassment is visible to others who are online, and the impact on the victim is often dire (Mishna et al., 2010).

20.1.3.1 Children and Adolescents

Studies conducted in several countries have shown that children and adolescents with ADHD are more likely to be victims and perpetrators of bullying than children without ADHD (Becker et al. 2017; Chou et al. 2018; Fite et al., 2014; Fogleman et al. 2018; Fonseca et al., 2019; Heiman et al. 2015; Holmberg & Hjern, 2008; McQuade et al., 2018; Murray et al. 2021; Örengül et al., 2021; Sciberras et al., 2012; Taylor et al., 2020; Timmermanis & Wiener, 2011; Unnever & Cornell, 2003; Wiener & Mak, 2009). Compared to their typically developing peers, children with ADHD are more likely to report that they are victims of bullying, but they are not more likely to report that they bully others (Taylor et al., 2020; Wiener & Mak, 2009). Their parents and teachers, however, report that they are also more likely to be perpetrators of bullying than children without ADHD (Wiener & Mak, 2009). When self-, parent-, and teacher reports are combined, Wiener and Mak found that 58% of 8- to 12-year-old children with ADHD were classified as being involved in bullying as a perpetrator (17%), victim (27%), or bully-victim (14%). In contrast, only 14% of children in the comparison sample of children without ADHD were involved in bullying. The frequencies are similar among adolescents (Pityaratstian & Prasartpornsirichoke, 2022; Timmermanis & Wiener, 2011). In addition, adolescents with ADHD are more likely than typically developing adolescents to be victims, perpetrators, or witnesses to cyberbullying (Heiman et al., 2015). Given the consistency of findings from these studies and the negative consequences of peer victimization, understanding the risk and protective factors for youth with ADHD is important.

20.1.3.2 Adults

Intimate partner violence is a form of bullying. Three longitudinal studies examined intimate partner violence in young adults with ADHD. Consistent with the findings about the long-term impact of being a perpetrator and victim of bullying in the general population, males with ADHD who had co-occurring conduct problems in childhood are more likely than other males to engage in intimate partner violence as young adults (Wymbs et al., 2012). Females with childhood ADHD, on the other hand, are more likely to experience physical intimate partner violence as young adults than typically developing adults (Guendelman et al., 2016). Young women who are most vulnerable to intimate partner violence had low social acceptance and problems with response inhibition and relational aggression in childhood (Youn et al., 2019).

20.1.4 Romantic Relationships

> *I don't invite people to my home, I don't call my friends, I don't get this thing about Facebook and I'm not active on other social media platforms. I end up outside of everything. I feel like a quitter. Other people have a social life, I'm behind closed doors, I don't exist.* (Nyström, 2020, p. 481; divorced man, age 50+)

Adults with ADHD in the United States are more likely to have marriages of shorter duration and to be separated or divorced than adults without ADHD (Wymbs et al., 2008). Adults with high levels of hyperactivity in Britain reported that they were less satisfied with their relationships with intimate partners than comparison adults (Moyá et al., 2014). Similarly, among adults in Israel (ages 30–53), partners of adults with ADHD reported less intimacy and lower levels of marital satisfaction than partners of adults without ADHD (Ben-Naim et al., 2017). This is not surprising because the skills associated with the development and maintenance of close friendships in childhood and adolescence are foundations for the development of high-quality romantic relationships. These skills include provision and acceptance of support, intimacy, and the ability to resolve conflicts (Wymbs et al., 2021), which, as discussed above, are less developed in children and adolescents with ADHD than their counterparts without ADHD.

Studies of the romantic relationships of adolescents and emerging adults with ADHD also provide data that explains why adults with ADHD tend to have less stable intimate relationships (see Wymbs et al., 2021 for review). Canadian adolescents with ADHD (ages 13–18) report having more romantic partners and having more casual sex within the previous year than typically developing peers. Girls with ADHD indicate that they have shorter relationships than girls without ADHD, and boys with ADHD report having their first sexual intercourse earlier than boys without ADHD (Rokeach & Wiener, 2018). Among college students in the United States and China, students with ADHD report more fear of intimacy than their counterparts without ADHD (Marsh et al., 2015). They also report lower relationship quality and that emotion regulation problems are associated with relationship quality (Bruner et al., 2015). Canu et al. (2014) compared the conflict resolution strategies of romantic couples attending a university in the United States on a dyadic task. The interactions of dyads where one member had ADHD-Combined Type involved fewer positive and more negative (i.e., criticisms, complaints, put-downs, defensiveness, and yes-but statements) conflict resolution strategies than couples where one member had ADHD-Inattentive Type or neither member had ADHD symptoms. Couples consisting of one member with ADHD-Combined Type were also less satisfied with their relationships.

20.1.5 Summary and Implications for Future Research

The evidence is incontrovertible that a significant proportion of children, adolescents, and adults with ADHD struggle with social relationships. Children with ADHD are more likely than other children to be rejected by their classmates and children with whom they interact frequently in settings, such as summer treatment programs.

Compared to their typically developing peers, children and adolescents with ADHD have fewer reciprocated or corroborated friendships, and children have friendships that are less stable. Children with ADHD have fewer friends who attend school than other children. Consistent with research showing that people have friends who are similar to them, children and adolescents with ADHD tend to have friends who have behavioral problems; adolescents with ADHD and conduct problems tend to be members of deviant peer groups; and emerging adults with high levels of ADHD symptoms befriend others with those symptoms. In terms of the quality of friendships, the friendships of children and adolescents with ADHD tend to have fewer positive features than those of their typically developing counterparts; children spend less time with their friends, and adolescents have friendships that are lower in mutual support and intimacy. Children with ADHD also have more conflict with their closest friends. The romantic relationships of adolescents and adults with ADHD are less stable and more conflictual than those of individuals without ADHD.

Bullying is a significant problem for children, adolescents, and adults with ADHD. Children and adolescents with ADHD are more likely to be perpetrators and victims of bullying, or to be both perpetrators and victims. Women with ADHD are more likely than other women to report that they are victims of intimate partner violence, and men with ADHD and conduct problems are more likely to be perpetrators of intimate partner violence. Although all of the above findings regarding children and adolescents pertain to males and females, some research suggests that girls are more at risk for social relationship difficulties.

Additional research on the social relationships of adults with ADHD would be informative. Given that adults with ADHD tend to have unstable relationships with intimate partners, social support from friends is especially important. However, I was not able to find research describing the number, stability, and quality of friendships among adults with ADHD or the characteristics of their friends. Similarly, other than self-reported challenges getting along with co-workers (Barkley, 2008), I could not find published research on the nature of those difficulties. Although there have been several reviews of the research on social relationships of individuals with ADHD, including systematic reviews and meta-analyses (Becker et al. 2012; Gardner & Gerdes, 2015; McQuade & Hoza, 2015; McQuade, 2020; Ros & Graziano, 2018), the systematic reviews and meta-analyses have not examined the research on bullying. This is likely because most of the research on bullying and ADHD was conducted recently.

20.2 Why Do Individuals with ADHD Have Challenges with Social Relationships?

Research has examined four related risk factors that are associated with social relationship difficulties in individuals with ADHD. (1) ADHD symptoms and symptoms of co-occurring externalizing (e.g., oppositional behaviors, aggression) and internalizing (e.g., anxiety, depression) disorders may be annoying to peers; (2) individuals with ADHD may not have acquired key social skills that enhance social relationships; (3) individuals with ADHD have problems with social cognition that interfere with the acquisition of social skills; and (4) emotion dysregulation may interfere with the performance of acquired social skills when engaging in an interaction. In addition, some positive characteristics are protective factors. Finally, parent and teacher behaviors in relation to children with ADHD are both risk and protective factors.

20.2.1 Symptoms of ADHD, Externalizing, and Internalizing Behavior Disorders

> *I talk too much, or not at all, too emotional, say things I shouldn't, no balance.* (Nyström et al., 2020, p. 479; adult, 50+)

The most obvious reason for the peer relationship challenges of individuals with ADHD is that ADHD symptoms such as excessive talking and off-topic and hostile responses are bothersome to peers (Kaidar et al., 2003; Mikami et al., 2007; Varma & Wiener, 2020). This may explain why peers' decisions as to whether they like or dislike a child with ADHD are made within hours (Ronk et al., 2011). Furthermore, children without ADHD are less likely to want to play with a child who is described as having ADHD symptoms (Harris et al., 1992). ADHD symptoms also increase the incidence of peer rejection among children with learning disabilities (Wiener & Harris, 1993).

A meta-analysis conducted by Ros and Graziano (2018) indicated that among children with ADHD, co-occurring conduct problems such as oppositional behaviors and aggression exacerbate their social relationship difficulties. Co-occurring conduct problems are associated with higher levels of peer rejection (Becker et al., 2012; Hinshaw et al., 1997; Jack et al., 2011; Melnick & Hinshaw, 2000) and being a perpetrator and victim of bullying (Fogleman et al., 2020; McQuade et al., 2018; Pityarastian et al., 2022; Rajendran et al., 2016). Children and adolescents with ADHD and conduct problems also have friendships with fewer positive qualities and more negative qualities (Normand et al. 2020; Rokeach & Wiener, 2022). Furthermore, among adolescents with ADHD, parent-rated prosocial skills mediate the relationship between oppositional behaviors and positive features of friendship quality (Rokeach & Wiener, 2022).

The association between peer relations and internalizing behaviors among children and adolescents with ADHD is mixed and depends on the type of social relationship (see Becker et al., 2012 for review). For the most part, studies do not indicate that anxiety and depressive symptoms are associated with peer status or friendship among children (Normand et al., 2020). Rokeach and Wiener (2022), however, found that anxiety was positively correlated with positive features of friendship quality among 15- to 18-year-old adolescents with ADHD, and this relationship was mediated by parent-rated social perspective taking (SPT). Rokeach and Wiener (2022) interpreted this finding as suggesting that adolescents with ADHD and co-occurring anxiety who have high levels of social perspective taking may engage in co-rumination with their friends (Rose et al., 2007). Finally, the evidence is clear that children and adolescents who are victims of bullying and cyberbullying are more likely to have elevated levels of anxiety and depression (Hu et al., 2021; Pityaratstian & Prasartpornsirichoke, 2022; Simmons & Antshel, 2021; Yang et al., 2013; Yen et al., 2014). These symptoms may make them easy targets of peer aggression or may be the consequence of being bullied.

20.2.2 Social Skills/Prosocial Behaviors

> *Every time I've tried to make a friend with someone, I failed epically... I did not know how to start it—what to do to initiate, let's say, a conversation even ... I thought that, in order to make friends, you have to annoy the person enough that they'd pay attention to you ... I didn't really understand what it took to be friends with someone.* (Maya Beristain & Wiener, 2020a, b, p. 286; male, age 16–18)

Studies on social skills or prosocial behaviors of children, adolescents, and adults with ADHD conducted in Canada, Israel, Taiwan, and the United States indicate that they are less socially skilled compared to their typically developing peers (Al-Yagon et al., 2011; Andrade & Tannock, 2014; Gewirtz et al., 2009; Huang-Pollock et al., 2009; Marton et al., 2009; Rints et al., 2015; Sacchetti & Lefler, 2017; Tseng et al., 2011) and that their challenges in that domain persist over time (Dupaul et al., 2018). In a meta-analysis of the research on social functioning of children with ADHD, Ros and Graziano (2018) found that the effect size for the association between ADHD and social skills in children was significant but small. Inadequate social skills among individuals with ADHD are associated with peer relationship difficulties in children and adolescents with ADHD (Andrade & Tannock, 2014; Morris et al., 2021; Rokeach & Wiener, 2022).

In several studies, the social skills of children and adolescents were assessed using the *Social Skills Improvement System* (SSIS; Gresham & Elliot, 2008). The SSIS is used frequently because it measures social skills and problem behaviors in pre-school children, school-age children, and adolescents; has self-report, teacher-report, and parent-report versions; and assesses several domains of social skills (social communication, cooperation, assertion, empathy, engagement, and self-control). As children and adolescents with ADHD have been found to have deficits in most of these skills according to parent and teacher reports (Marton et al., 2009; Rokeach & Wiener, 2022), investigators typically use the total social skills score in their studies examining predictors of social skills.

Peer group entry is a skill that individuals need to acquire that involves the broad base of domains measured on the SSIS. Children use this skill in the schoolyard when they want to join a group that is having a conversation or playing a game they want to play. Adults use this skill at work and when attending social gatherings. A competent entry strategy is to hover next to the group, observe the activity or conversation, and then say something that is relevant to that conversation or activity (Dodge et al., 1983). In a study of 7- to 12-year-old boys with ADHD, Ronk et al. (2011) found that they use this strategy. Unfortunately, they also make more attention-getting comments or actions and talk more about themselves than their counterparts without ADHD. These self-centered behaviors elicit a negative response from the group. These behaviors are also associated with more conflict with friends (Normand et al., 2011).

In part, the social skills difficulties of individuals with ADHD are related to their ADHD symptoms and challenges with executive functioning. For example, as described in the DSM-5-TR manual, "inadequate or variable self-application to tasks that require sustained effort is often interpreted by others as laziness, irresponsibility, or failure to cooperate" (American Psychological Association, 2022, p. 63). Similarly, inattentiveness is associated with making off-topic responses in a social communication task (Mikami et al., 2007) and excessive talking with dominating conversation (Landau & Milich, 1988). There is mixed evidence that difficulties with executive function are associated with problematic social skills in children and adolescents with ADHD. Working memory has been found to be associated with children's parent-rated social problems (Chiang & Gau, 2014; Kofler et al., 2011). Executive functions, however, were not associated with social skills in an Israeli sample of children with ADHD (Al-Yagon et al., 2014).

Gresham (1986) distinguished between social skill deficits (i.e., the individual has not learned the skill) and social performance deficits (i.e., the individual has learned the skill but does not perform it in specific situations). This question is important in relation to individuals with ADHD, whose inattention and impulsivity may prevent them from consistently using the skills they have. This issue is addressed below by reviewing studies on social cognition and emotion dysregulation.

20.2.3 Social Cognition

> Dan*: But most of the time they're just kidding with the other boy.* Interviewer*: They're not kidding with you?* Dan: *Yeah, sometimes they are.* Interviewer*: Is it hard to tell when they're just kidding?* Dan: *Yes!!!!* Interviewer: *Does the way you react change whether it was kidding?* Dan*: Yeah, sometimes.* Interviewer*: How can that change it?* Dan*: Like if they were kidding I might not yell at them and stuff, but I don't know that.* (Shea & Wiener, 2003, p. 67; male, age 11–13)

Social cognition (sometimes referred to as social information processing) is a global term that refers to the cognitive mechanisms that assist with perceiving and understanding social interactions (Staub & Eisenberg, 1981). In a meta-analysis of the research on social functioning of children with ADHD, Ros and Graziano (2018) found that the effect size for the association between ADHD and social information processing in children was significant but small.

Crick and Dodge (1994) developed a model of the mechanisms that contribute to social adjustment that explains the relationship between social cognition, social skills, and social relationships. Although the model was developed to explain children's interactions, it is also appropriate for understanding the social interactions of adolescents and adults. The model consists of six steps that are circular. The first two steps in a social interaction are encoding and interpreting social cues. The third step is decision-making regarding goals in a specific social interaction (e.g., playing the game or obtaining the object they want; making friends; providing help and support). The fourth and fifth steps are planning a response, which involves accessing stored solutions for responding to a social problem, predicting the consequences of these potential responses, and evaluating whether they would be appropriate for the situation. Crick and Dodge propose that individuals have a database of acquired social rules and behaviors that they access in these situations (i.e., social skills). The sixth stage is behavioral enactment (e.g., grabbing a toy or object the other person has, apologizing, asking for help, or suggesting a compromise). In a social context, peers evaluate the behaviors that were enacted and respond accordingly. Their responses then stimulate the cycle to begin again. Although the Crick and Dodge model is helpful in understanding the social relationship difficulties of children, adolescents, and adults with ADHD, and will be referred to below, the model does not consider important contextual factors (e.g., parenting, teacher behaviors) that may influence their acceptance by peers.

Several studies examined the encoding and interpretation aspects of social cognition. This involves emotion recognition, empathy, theory of mind, and attributions of intent. Children with ADHD have more challenges with the recognition of emotional facial expressions (Kara et al., 2017) and with encoding nonverbal information (Hilton et al., 2020) than children without ADHD. Although children with ADHD obtain lower scores on ratings of empathy compared to their typically developing peers, the evidence suggests that these low scores are associated with oppositional and aggressive behavior (Deschamps et al., 2015; Marton et al., 2009). Groen et al. (2018) found a relationship between ADHD symptoms and empathy in adults; however, the role of co-occurring conduct problems was not assessed. Furthermore, a hostile attribution bias is associated with aggression as opposed to ADHD symptoms (Milich & Dodge, 1984). The evidence linking ADHD with delays in acquiring simple theories of mind is weak (Pineda-Alhucema et al., 2018).

Children and adolescents with ADHD have challenges with social perspective taking (SPT: King et al., 2009; Kara et al., 2017; Marton et al., 2009; Timmermanis, 2015). SPT refers to the ability to understand a social situation from another person's perspective and use that information to solve social problems (Selman, 1971) (i.e., steps 1–5 in the Crick and Dodge, 1994 model). It is typically assessed by asking the participant to solve a social dilemma. A higher SPT is achieved when a person is able to coordinate the perspectives of the protagonist and significant other to obtain a solution. Children and adolescents with ADHD have challenges with SPT (Marton et al., 2009; Sibley et al., 2010; Timmermanis, 2015). They are less able to define the problem accurately and identify the feelings of the protagonist and significant other (encoding and interpretation); the strategies they propose typically satisfy the goals of the protagonist, and they generate fewer strategies that involve collaboration between the protagonist and significant other. They also have more challenges with evaluating the potential outcomes of the strategies (Marton et al., 2009). This may explain why children with ADHD generate a more hostile response to provocation (King et al., 2009). Furthermore, children's ADHD status predicts overall SPT when language skills, intellectual ability, and conduct problems are controlled, and SPT moderates the association between ADHD status and self-reported social skills (Marton et al., 2009; Timmermanis, 2015).

The studies on social cognition reported above suggest that the poor social skills of children and adolescents with ADHD are associated, at least in part, with social cognitive deficits. Whether they also have a social performance deficit is addressed by examining the research on emotion dysregulation in youth with ADHD.

20.2.4 Emotion Dysregulation (ED)

> *I had a really bad temper. I HAD a temper. But now I never like get very angry and stuff. And usually when something like really, really, really bad happens to me that I cannot, I cannot stand, that I can't ignore, and then I get really, really angry and my face turns really red and I go just berserk.* (Shea & Wiener, 2003, p. 66; male, age 11–13)

As described in reviews of research by Bunford et al. (2015) and Bunford (2020), emotion regulation is the process of modifying emotions in order to adapt to internal stimuli (e.g., pain) or stimuli in the environment. In infants and toddlers, emotion regulation is typically accomplished by caregivers who soothe or distract the child. As children get older, they play an increasing role in regulating their own emotions. For children, adolescents, or adults, depending on the context and the emotion, high levels of emotional expression (e.g., excitement or joy when the individual or an important other achieves a goal or gets an opportunity) are adaptive, and in other situations, high levels of emotional expression (e.g., anger or fear) are typically maladaptive. Emotion dysregulation refers to a deficit in regulating emotions. It is associated with many externalizing and internalizing behaviors, including noncompliance, aggression, anxiety, and depression, and is a feature of several disruptive behaviors and neurodevelopmental disorders.

The research is clear that children and adolescents with ADHD have challenges regulating their emotions when compared to individuals without ADHD (see Bunford, 2020; Bunford et al., 2015 for review). Research also suggests that ED in individuals with ADHD is associated with social skills and social relationship difficulties. Among 8- to 10-year-old children attending a play group, emotion dysregulation mediated the association of ADHD symptoms with negative peer and staff ratings of liking (Lee et al., 2018). Not surprisingly, ED is associated with aggression among 6- to 12-year-old boys with ADHD (Melnick & Hinshaw, 2000). After controlling for oppositional defiant disorder, ED mediates the association between ADHD and social skills in adolescents (Bunford et al., 2015; Cleminshaw et al., 2020). Among adolescents with ADHD, ED is associated with being a perpetrator or victim of bullying (Yilmaz Kafali et al., 2021), fewer supportive interactions with best friends, affiliation with a deviant peer group, and higher levels of aggression with peers (McQuade et al., 2021). In a study with an undergraduate sample, ED mediated the association between ADHD symptoms and romantic relationship quality (Bruner et al., 2015). Similarly, among adults with ADHD, ED mediated the association between ADHD and overall functional impairment, internalizing symptoms, and relationship satisfaction (Bodalski et al., 2019).

20.2.5 Within-Child Protective Factors

Research has identified some protective factors that are associated with enhanced social relationships in individuals with ADHD. Although negative behaviors while engaging in sports are associated with lower levels of peer acceptance, athletic competence is associated with higher peer acceptance among children with ADHD (Lopez-Williams et al., 2005). Importantly, having a close high-quality friendship is a protective factor with regard to peer victimization in typically developing children and children with ADHD (Cardoos & Hinshaw, 2011; Schmidt & Bagwell, 2007).

20.2.6 Parent and Teacher Behaviors as Risk and Protective Factors

Various aspects of parent and teacher behaviors are associated with the peer status and social skills of children with ADHD. Among parents of children with ADHD, those who report that they have an authoritative parenting style have children who are more accepted by peers (Hinshaw et al., 1997). Mikami et al., (2010a) observed the interactions of 6- to10-year-old children with and without ADHD while playing together and the interactions of their parents in the same context. These behavioral measures were used to predict child peer status, which was assessed through sociometric nominations in the play group and by teacher reports of the children's peer status. Parents of children with ADHD host fewer playdates than parents of typically developing children and are more critical of their children when playing with them. Peer acceptance as rated by teachers is associated with parents of children with ADHD who socialize more with other adults and who display warmth in their interactions; this association is not evident in parents of children without ADHD. Similarly, among children with ADHD (but not comparison children), peer rejection is associated with fewer playdates hosted by parents. The results of this study suggest that parenting behavior among parents of children with ADHD is even more important than among typically developing children.

Attachment with mothers and fathers (Al-Yagon, 2016) and parent social competence (Jia et al., 2021) are associated with higher levels of social skills in children with ADHD, higher levels of paternal warmth are associated with positive peer relationships (Hurt et al., 2007); and higher levels of positive parenting and lower levels of negative parenting behaviors predict social skills over and above child inattentive symptoms (Haack et al., 2016). In contrast, maternal ADHD symptoms are associated with higher levels of parent-rated child social problems but are not associated with teacher-rated child social problems (Griggs & Mikami, 2011). Furthermore, maternal overprotection is associated with negative peer relationships (Kawabata et al., 2012).

McQuade et al. (2021) conducted a longitudinal study beginning when the children with ADHD were 8–12 years of age (time 1); the children were re-assessed 5–6 years later (time 2). The question McQuade et al. examined was whether parent emotion socialization and child ADHD symptoms at time 1 predict adolescent ED, adolescent reports of positive support and negative interactions with their best friends, and deviant peer group affiliation at time 2. Parent emotion socialization refers to their reactions to their children's expression of negative emotions. Supportive parent reactions, include helping children express the emotion verbally, suggesting strategies to cope with their emotions, and helping them solve the problems that elicited the negative emotions. Unsupportive parent reactions, include punishment and minimizing the severity of the stimulus that elicited the emotion, as these reactions are likely to increase children's negative emotions. Both lower levels of supportive and higher levels of nonsupportive parent emotion socialization at time 1 predicted higher levels of ED at time 2. ED at time 2 predicted lower levels of adolescent reports of support from their best friend and higher levels of adolescent reports of negative interactions with their best friend. ED mediated the relationship between low levels of parent-emotion socialization at time 1 and deviant peer group affiliation.

A positive teacher-child relationship is associated with higher levels of social skills among children with ADHD (Jia et al., 2021). Teacher behaviors play a role in determining whether peers like or dislike children with ADHD (Mikami & Mercer, 2017). Children (ages 6–9) with ADHD are more likely to be liked by their peers when their teachers praise their personal strengths. Conversely, teachers' public criticism of negative behaviors increases the extent to which children are disliked. Teachers' praise for merely complying with rules, however, does not influence peer status.

20.2.7 Summary and Implications for Future Research

Children and adolescents with ADHD have challenges with decoding emotions and d with social perspective taking, which are associated with low levels of social skills. Although the social skills of children and adolescents with and without ADHD predict parent ratings of their peer relations and friendship quality, I was not able to find published research that examined the specific skills associated with peer acceptance, peer rejection, friendship, bullying, and stable romantic relationships.

Several studies have shown that ED in children and adolescents with ADHD is associated with social skills, peer rejection, low levels of positive features, and high levels of negative features in relationships with close friends. It is also associated with both externalizing and internalizing behaviors/disorders. While externalizing behaviors are associated with a hostile attribution bias, low levels of empathy, and deviant peer group association, the evidence suggests that children and adolescents with ADHD who do not have high levels of externalizing behaviors are not at high risk for these social cognitive difficulties or deviant peer group association. The question of whether individuals with ADHD have a social skills deficit or a social performance deficit is not clearly answered by the research. The findings that SPT is positively associated with social skills and ED is negatively associated with social skills suggest that both are likely.

Parent behaviors (attachment, coaching, modeling of interactions with friends, and emotion socialization) and teacher behaviors (e.g., praise) are associated with enhanced peer acceptance and friendship in children and adolescents with ADHD. Conversely, parent and teacher criticism is associated with peer rejection and low-quality friendships. Although there is considerable research on social relationships of children with learning disabilities in various types of special education and inclusive settings (Wiener & Tardif, 2004), this has not been investigated in children with ADHD. Several adolescents participating in a qualitative study, however, reported that they met many of their friends while receiving special education assistance in a resource room (Maya Beristain & Wiener, 2020a).

There are some important gaps in the research that suggest implications for future research. First, the research is mainly confined to studies of children or adolescents, with few of the studies being longitudinal. Second, with the exception of the McQuade et al. (2021) study, I did not find longitudinal studies that investigated paths to different types of social relationship difficulties (peer status, friendship, bullying, and romantic relationships). Third, the studies on social cognition do not include resistance to peer pressure, which is important because adolescents and adults with ADHD have higher rates of substance use than their peers and start using substances earlier (see Kennedy et al., 2012 for review). A series of studies with adolescents with learning disabilities indicate that they are more likely than typically achieving adolescents to conform to peer pressure and engage in misconduct, in part because they do not understand that statements that they will be unlikely to be caught or that they will be rejected by their peers are used as a form of pressure (Bryan et al., 1989; Pearl et al., 1990; Pearl & Bryan, 1992). As these studies did not provide data on the proportion of the participants in their samples of adolescents with learning disabilities who had co-occurring ADHD, replicating them with samples of adolescents with ADHD may be informative. Fourth, other than athletic competence, research has not examined protective factors, such as having a sense of humor (or other behaviors and characteristics valued by peer groups), cognitive ability, and high levels of empathy.

20.3 What Are the Perspectives of Individuals with ADHD on Their Social Relationships?

There is some evidence that the social relationship difficulties of children, adolescents, and adults with ADHD affect their wellbeing. Longitudinal studies, for example, have indicated that peer rejection in childhood is associated with behavioral and mental health problems in adolescence, including externalizing and internalizing disorders and eating disorders (Mikami & Hinshaw, 2006; Mrug et al., 2012). In this section, I review research comparing self-perceptions of social competence and behavioral conduct, self-esteem, loneliness, and attributions for social and behavioral problems in children, adolescents, and adults with and without ADHD. I then describe the findings from three qualitative studies that provide a more in-depth understanding of their experience of social difficulties.

20.3.1 Research Comparing Individuals With and Without ADHD

According to Harter (2012), self-perceptions are domain-specific and become more differentiated over time. Thus, by the time children are 7 years of age, they are able to rate their competence in domains, such as scholastic competence, social skills, and behavioral conduct. They are also able to report on their global self-worth or self-esteem. Not surprisingly, children and adolescents with ADHD have lower self-perceptions of social competence and behavioral conduct and lower self-esteem than their typically developing counterparts (Kaidar et al., 2003; Colomer et al., 2020). However, as first identified by Hoza et al. (2002), when compared with parent or teacher ratings of their social competence and behavioral conduct, children overestimate their competence; this has been referred to as a positive illusory bias or self-enhancement bias (e.g., see Colomer et al., 2016 for review). The self-enhancement bias declines in adolescents and emerging adults (Hoza et al., 2010) and is evident in less than half of them (Bourchtein et al., 2017). As reviewed by Colomer et al. (2016), children with ADHD who also have high levels of depressive symptoms are more realistic in their self-appraisals, a finding that suggests that it may protect against depression.

The attributions of children, adolescents, and adults with ADHD for their social relationship difficulties are important to consider because they may influence their response to intervention. Compared to children and adolescents without ADHD, children and adolescents with ADHD are more likely to view their self-identified most problematic behaviors as uncontrollable, pervasive (i.e., occurring in more situations and stable over time), and stigmatizing (i.e., embarrassing and bothersome to others) (Kaidar et al., 2003; Varma & Wiener, 2020).

Loneliness is a feeling of distress related to having lower levels of social connectedness than desired (Margalit, 2010). Researchers distinguish between social loneliness, which involves the person feeling that their social network is inadequate, and emotional loneliness, which involves a feeling that intimate relationships are inadequate (Al-Yagon, 2016; Hoza et al., 2000; Margalit, 2010). Given the social relationship challenges experienced by individuals with ADHD, it is not surprising that they experience loneliness. Children with ADHD have higher levels of parent-reported, but not self-reported, loneliness (Heiman, 2005; Laslo-Roth et al., 2021). The difference in parent and child reports of loneliness may be associated with the self-enhancement bias. Furthermore, among children with ADHD, children with fewer friends, more negative interactions with their friends, and internalizing problems experience higher levels of loneliness (Smit et al., 2020). Adolescents with ADHD experience higher levels of social and emotional loneliness than typically developing adolescents, and fewer close friendships are associated with higher levels of emotional loneliness (Al-Yagon, 2016; Houghton et al., 2020). Furthermore, both social and emotional loneliness mediate the association between ADHD diagnosis and depression (Houghton et al., 2020). ADHD symptoms in older adults (ages 60–94) are associated with higher levels of emotional loneliness (Michielsen et al., 2015).

20.3.2 Subjective Experience

The subjective experience of social relationships among people with ADHD was examined in three qualitative studies. The sample for the Shea and Wiener (2003) study was four boys (ages 11–13) who, while participating in a previous study on the self-perceptions of children with ADHD, indicated that they had been bullied by peers. Their parents and teachers were also interviewed. The sample of the Maya Beristain and Wiener (2020b) study consisted of nine 16- to 18-year-old adolescents (four boys, five girls) who had previously been participants in a study on family and peer relationships among adolescents with ADHD. The participants from both of these studies lived in a large culturally and linguistically diverse urban area in Canada. The third study was conducted by Nyström (2020) with a sample of ten adults in Sweden, nine of whom were between 50 and 60 years of age and one of whom was over 70. Seven of the participants in this study were female. Notably, none of the participants had an intimate partner at the time of the study, and six were unemployed or on sick leave. In all three studies, semi-structured interviews were conducted to learn about the participants' perspectives on their social relationships. The Swedish study also examined the participants' experiences in the workplace. The findings from these qualitative studies were similar to those found in quantitative studies comparing individuals with and without ADHD. The extent of the emotion conveyed in the participants' statements, however, shows the despair they felt about their social relationships (see quotations from these studies introducing the sections of this chapter).

In spite of the age differences in the samples in these studies, the themes pertaining to social relationships are remarkably similar. The children, adolescents, and adults with ADHD all talked about being, feeling, or being seen as *different* or *weird*. The adolescents and adults indicated that other people believe that they are not like them because they are disorganized and forgetful, have difficulty understanding social norms, and have poor social skills. They also referred to being different because of problems with ED that complicate various aspects of their social relationships. The second common theme was *social isolation* or *social exile*. Many of the participants in these studies were distressed because they were rejected by most of their peers in school or the workplace, indicated that they had few, if any, friends, were lonely, and felt incapable of establishing close friendships. Their experience of social isolation was especially acute during middle school.

Some of the participants in the Maya Beristain and Wiener (2020b) and Nyström (2020) studies provided some hopeful reflections about their social relationships and quality of life. Most of the older adolescents in the Maya Beristain and Wiener study had developed at least one close and supportive friendship by the time they were in grade 11. Their friends were similar to them in that they also had ADHD or learning disabilities. Some of the older adults discussed helpful strategies, such as being persistent, engaging in physical activity, and living in a structured environment.

20.3.3 Summary and Implications for Future Research

Challenges with peer acceptance, developing close friendships, not having stable relationships with an intimate partner, and being bullied are associated with emotional distress in children, adolescents, and adults with ADHD throughout their lifetimes. During adolescence, they are aware that they are not socially competent, feel that others view them as different or weird, and suffer from social and emotional loneliness. These feelings persist into older adulthood.

There is considerable research on the experiences with social relationships of children and adolescents with ADHD, and two studies with older adults. I was not able, however, to identify published studies on the experiences of challenges in the social domain among adults who are 19–50 years of age or studies conducted outside of North America and Europe. Furthermore, the participants in the three qualitative studies were disproportionately female, and all of the participants struggled with social relationships. It is possible that women with ADHD and social difficulties opt to participate in this type of research because of the opportunity to talk to someone about their problems.

20.4 What Is the Efficacy of Interventions Designed to Improve Social Functioning?

MYmind . . . really helped me kind of like bridge the gap between myself and other people. . . It really helps in social situations, like if I run out of things to say and I start thinking, oh god, I'm out of things to say. What do I do next to keep this conversation flowing and not awkward? Then I take a breathing

> *space for a minute, and my friends are usually like, Matt what are you doing? I'm like, shhh. And then when I come back from doing that breathing space or what- ever it was called, then I generally find that I'm more able to communicate with people.* (Haydicky et al., 2017, p. 1028, boy age 17)

Evidence-based psychopharmacological and psychosocial interventions for children, adolescents, and adults with ADHD typically focus on reduction of ADHD symptoms and oppositional behavior (see Brinkman et al., 2020; Chimlikis et al., 2018; Evans et al., 2018; Fabiano & Pyle, 2019; Sprich & Burbridge, 2020; Wiener & Bedard, 2021 for recent reviews). The interventions reviewed in these papers, include behavioral parent training, classroom behavior management, cognitive behavior therapy, coaching, and mindfulness interventions. As the focus of this chapter is social relationships, I confine my review of interventions to studies that measured social skills and social relationship outcomes. I begin this section by describing the findings from research on the social skills training (SST) for children and young adolescents and discussing the components of these interventions that are important for the acquisition of social skills, including the extent to which parent and teacher involvement enhances positive outcomes. I then describe the research on coaching, cognitive behavioral therapy, mindfulness-based interventions, and marital therapy for adolescents and adults with ADHD. Finally, I discuss the role of pharmacotherapy in improving the social skills and relationships of individuals with ADHD.

20.4.1 Social Skills Training (SST)

Social skills training involves individual or group therapy that focuses on teaching social skills that are required for positive peer relationships. Most SST programs for children and adolescents with ADHD are administered by a therapist to groups of four to eight children once a week for 8–12 weeks. In some of the programs, parents of the children receiving SST meet in small groups with a therapist where they learn about ADHD, behavior management, and strategies to support their children's social skills (Mikami, 2017; Willis et al., 2019). The skills that are typically taught in programs for children and adolescents with ADHD are communication (e.g., initiating and maintaining conversation, assertion, and conflict resolution), emotion regulation (e.g., accepting undesirable outcomes, responding to teasing, and other types of provocation), social perspective taking (e.g., interpreting social cues, communicating empathy), and positive interpersonal behaviors (e.g., group entry, sharing, and turn taking) (Willis et al., 2019). In the groups with the children and adolescents, therapists either use a coaching approach, a social problem-solving approach, or a hybrid of the two (Wiener & Harris, 1997). The key components of coaching are modeling, role play, performance feedback, and praise for appropriate behavior (Willis et al., 2019). In groups in which social problem solving is emphasized, children are presented with problem situations and asked to identify the social problem, generate alternative courses of action, figure out the consequences of each alternative, and identify the best solution. In programs with a social-problem-solving emphasis, after presenting a problem, therapists ask questions such as, *what's happening? what will happen if...? What are the pros and cons of...? What is your decision,* and *Did it work?* In order to promote engagement, acquisition of the skills, automaticity, and generalization, Wiener and Harris (1997) suggested using a combination of coaching and social problem-solving approaches, highly interesting materials, multiple examples of the same skill, and delayed, intermittent, and vicarious reinforcement.

Studies with high methodological rigor evaluating the types of clinic-based SST interventions described above show modest improvement in social skills as reported by the child and parent participants but not by the children's teachers (Evans et al., 2014; Mikami, 2017; and Willis et al., 2019). Nevertheless, children who have high levels of oppositional behaviors do not appear to benefit from SST, partly because they may not comply with the instructions and because there may be behavioral contagion in groups with more than one oppositional child (Willis et al., 2019). Due to the enormous practical challenges of using sociometric measures to evaluate SST programs, it is not surprising that these measures of peer acceptance and rejection have not typically been used in evaluation studies of SST interventions. The results of the Multimodal Treatment Study, however, showed no changes in peer status following a combination of SST, behavior management, and medication management (Hoza et al., 2005).

Mikami (2017) suggested that the reason for the best modest improvement in social skills training may be because children with ADHD have a performance deficit as opposed to a knowledge deficit. Furthermore, even when they acquire social skills following SST, they may still have a negative reputation with peers. She suggested that efficacious interventions for improving children's social skills and relationships should include embedding the intervention in a social context (e.g., a summer treatment program), involving parents and teachers, including leveraging them to change peer reputational biases, and recruiting peer coaches. In response to the problems, she identified with traditional SST interventions, Mikami and her colleagues developed the *Parent Friendship Coaching* (PFC) and *Making Socially Accepting Inclusive Classrooms* (MOSAIC) programs, both of which are manualized treatments designed to enhance the social skills and friendship quality of children with ADHD.

PFC involves eight (Mikami et al., 2010b) or ten (Mikami et al., 2020a) 90-min group sessions with parents, each of which targets a specific skill. Strategies used include handouts, activities, and role plays to explain the skill, assignment, and discussion of homework, and group viewing and discussion of videotapes of parents working with their children. During the 10 weeks of the program, parents arrange play dates for their children, and the issues that occur during the playdates are a major focus of the discussion. The components of the program include psychoeducation about ADHD and children's friendship; teaching parents how to develop a positive parent-child relationship; strategies for choosing a compatible playmate; dealing with children's defiance; preparing for a playdate; strategies for teaching dyadic play skills; minimizing boredom and conflict during the playdate; dealing with negative emotions; teaching conversation skills; preparing children for being a guest at their friends' home; and helping children make new friends.

PFC was evaluated through two randomized control trials. In the first study, the treatment participants were compared to a no-treatment control group (Mikami et al., 2010), and in the second study, they were compared to a group treatment of similar length where parents received psychoeducation about ADHD and provided advice and support to the other group members (Mikami et al., 2020a). When compared to the no-treatment control group (Mikami et al., 2010b), parents of children in the PFC condition reported reduced arguments and disengagement during play dates and more positive social skills post-treatment. Teachers reported that following intervention, more classmates accepted and fewer children rejected the child whose parents participated in PFC. When compared to children whose parents were in the psychoeducation and discussion group (Mikami et al., 2020a), parents of the children in the PFC group reported that their children had better social skills and engaged in less conflict than parents in the discussion group, and these gains were maintained at 8-month follow-up. These results were corroborated using observational measures. These behavioral changes, however, did not generalize to friendship quality as measured on questionnaires or by observing the children interact in the competitive car-race task used in the Normand et al. (2011) study.

Although originally developed to target social acceptance of children with ADHD, the MOSAIC program is a universal design intervention in that it was intended to facilitate positive relationships among all children in a classroom (Mikami et al., 2020b, 2021). The program involves training classroom teachers from grades 1–5 to use the following strategies: reviewing and reinforcing expectations for positive behaviors such as cooperation and being kind to others; greeting individual children personally; spending 3–5 min with each child individually, during which time they show interest in the child; highlighting children's positive attributes; and correcting children discreetly. Findings from two randomized control trials (Mikami et al., 2020b, 2021) showed that the fidelity of teacher implementation of MOSAIC was strong and that the strategies were associated with more positive teacher-student relationships for children with and without high levels of parent- and teacher-rated ADHD symptoms. Compared to children with high levels of ADHD symptoms in control classrooms, students with high ADHD symptoms in MOSAIC classrooms also had a reduction in impairment, according to teacher ratings. MOSAIC, however, was not associated with changes in peer acceptance and rejection among children with high levels of ADHD symptoms, according to sociometric ratings.

To conclude, SST interventions are associated with modest improvements in social skills, parent-rated gains in peer relations in those programs where parents are involved in implementation, and teacher-rated gains in peer relations in those programs where teachers are involved in implementation. The research suggests that parent and teacher involvement is very important. The interventions that have been evaluated by rigorous research, however, have not shown gains in peer status using sociometric ratings in regular classroom contexts (Hoza et al., 2005; Mikami et al., 2020b; Mikami et al., 2021) or friendship quality (Mikami et al., 2020a).

20.4.2 Psychosocial Interventions for Adolescents and Adults

Adolescents and adults with ADHD typically interact with their friends, classmates, and co-workers in contexts where they are not supervised by their parents. Adolescents also have several teachers who see them for short periods each day, so they are typically unable to substantially influence peer relations (Evans et al., 2005). Consequently, interventions focus on providing adolescents and adults with ADHD with strategies that they can use in various contexts. As described in several reviews of the literature, the most frequently used psychosocial interventions for adolescents and adults with ADHD are psychoeducation (Murphy, 2015), coaching (Kubik, 2010), teaching executive functioning skills (Sibley, 2020; Langberg et al., 2020), cognitive behavior therapy (Knouse et al., 2017; Sprich & Burbridge, 2020), mindfulness-based interventions (Cairncross & Miller, 2020; Chimiklis et al., 2018; Evans et al., 2018; Oliva et al., 2021; Poissant et al., 2019), and marital therapy (Wymbs et al., 2021). As discussed in these reviews, executive function training is associated with improvements in organization, time management, planning skills, and academic functioning in adolescents. Cognitive behavior therapy and mindfulness treatments are effective in reducing ADHD symptoms, anxiety, and depression. Below, I review studies where social skills or social relationships were measured as outcomes.

Three studies of psychosocial interventions for adolescents with ADHD assessed whether the intervention was associated with changes in social skills or peer relations. Schultz and Evans (2015) developed and evaluated the *Challenging Horizons Program*. The components of this program are teaching strategies to enhance executive functioning (memory, time management, and planning), individual solution-focused counseling, behavioral contracts, consultation with teachers, and an interpersonal skills group. Although a randomized control study showed that the adolescents made gains in executive functioning and academic performance, no improvements were found in parent- and adolescent-reported social skills. Haydicky et al. (2015) evaluated an adaptation of the *My Mind* program, a mindfulness CBT program that was developed by van de Weijer-Bergsma et al. (2012). Adolescents with ADHD and their parents participated in eight sessions that included psychoeducation about ADHD, mindfulness meditation, addressing cognitive distortions, and interpersonal communication. In addition to reductions in adolescent inattention, anxiety, conduct problems, and aspects of parenting stress, parents reported that their children's peer problems were reduced during the treatment period compared to a 3-month baseline. These gains were maintained at a 3-month follow-up. Gardner et al. (2019)

examined the efficacy of the *Program for the Evaluation and Enrichment of Relational Skills* (PEERS) program for developing friendships. PEERS is a 14-week parent-assisted program in which adolescents are taught social skills, including initiating and maintaining a conversation, using social media and other electronic communication appropriately, group entry, and using humor. The majority of parents and adolescents reported that the adolescents initiated a new friendship during the treatment period, and they spent more time with their friends. This study, however, did not have a control group.

Couples therapy is a promising intervention for adults with ADHD who have an intimate partner (Wymbs, 2021). Wymbs & Molina (2015) found positive effects of a couples' therapy intervention that combined CBT and the teaching of social problem solving. The role of the partner of the person with ADHD in this treatment was to support the individual with ADHD in acquiring the skills. In addition to the reduction in ADHD symptoms as reported by the adults with ADHD and their partners, the participants reported less relationship negativity and conflict-inducing behaviors following the treatment. Wymbs (2021) suggested that treatments that address conflict in romantic relationships where one partner has ADHD include the following: psychoeducation about ADHD; coping skills for partners; integrating CBT to address symptoms and impairment; teaching parenting skills; and stimulant medication.

20.4.3 Psychopharmacological Interventions

As reviewed by Brinkman et al. (2020) and Connor (2015), medications such as methylphenidate or atomoxetine on their own or in combination with behavioral interventions are effective in reducing ADHD symptoms as well as other functional impairments such as conduct problems in children and driving in adolescents and adults. I was not able to find published studies that compared medication with a placebo in terms of potential gains in social relationships, prosocial behaviors, or social skills. Children and adolescents with ADHD, however, are less likely to be perpetrators or victims of bullying while on methylphenidate, according to self-, parent-, and teacher-reported data (Karaosman & Gumus, 2022). Both methylphenidate and atomoxetine are associated with improvements in parent- and self-reported peer relations (Shang et al., 2020). Furthermore, adolescents attending a summer treatment program who were given methylphenidate had improved social behaviors when the dose was low; higher doses were associated with fewer positive effects and more negative effects (Smith et al., 1998). Although the results of these studies are promising, due to the absence of placebo control groups, it is not possible to establish whether these changes are associated with the medication.

Several studies have examined whether medication, on its own or in combination with other treatments, such as behavioral parent training, social skills training, and school behavioral programs, is associated with positive social behaviors and relationships. The results of these studies are mixed. In general, children's prosocial behaviors improve over time, with medication groups and medication plus social skills training or behavior management groups achieving some gains in terms of social skills (e.g., Abikoff et al., 2004; Chacko et al., 2005; Hinshaw et al., 1989; Waxmonsky et al., 2010) but not peer status using sociometric measures (Hoza et al., 2005).

20.4.4 Summary and Implications for Future Research

Psychosocial interventions, including SST, CBT, and mindfulness treatments, have been found to be effective in reducing ADHD symptoms and negative behaviors in children, adolescents, and adults. CBT and mindfulness CBT are also helpful for anxiety and depression (Oliva et al., 2021). Some improvement in parent-rated and self-reported social skills is evident as a result of SST (Willis, 2019), especially when parents engage in friendship coaching (Mikami et al., 2020a). Although pharmacological interventions are effective in reducing negative behavior, studies have not convincingly demonstrated that there is a concomitant increase in positive social behaviors and social relationships.

This review suggests that social skills and social relationships should more often be assessed in intervention studies for children, adolescents, and adults with ADHD. Systematic reviews and meta-analyses have shown that the methodological rigor of the majority of studies is low (e.g., Knouse et al., 2017; Oliva et al., 2021; Willis, 2019); these studies typically use pre-post designs without a control group. With few exceptions (e.g., Haydicky et al., 2015, 2017), studies have not used mixed methods, which might elucidate mechanisms of change.

There are five types of interventions that may be helpful to improve social skills and social relationships of individuals with ADHD that have not been reported in the research literature and may be promising (Kubik, 2010; Wiener & Bedard, 2021; Wymbs, 2021).

1. Although peer and cross-age tutoring has positive effects on academic, social, emotional, and behavioral functioning (Bowman-Perrott et al., 2014), this has not been examined explicitly with children and adolescents with ADHD.
2. Peer conflict mediation has been shown to reduce schoolyard conflicts and aggression (Burrell et al., 2003). Furthermore, Cunningham et al. (1998) found that mediators with a history of interpersonal conflict, including children with ADHD, had fewer conflicts when they participated in the program as mediators.
3. Conjoint behavioral consultation is an intervention typically used by school psychologists to modify children's behavior in the classroom and at home. Psychologists work with parents and teachers to engage in joint problem solving regarding children's behavioral difficulties. Although typically used to reduce negative behaviors, Colton et al. (1998) used it with three children with ADHD to improve cooperative play behavior. The results of the study, which used a single subject, multiple baseline design, were promising. Future studies should evaluate whether the conjoint behavioral consultation model in combination with MOSAIC and parent friendship coaching would be effective in improving the social skills and relationships of children with ADHD.
4. Adults with ADHD sometimes employ coaches whose main role is to assist them with organization, time management, and planning. It may be helpful to train coaches to also provide guidance on solving social problems in the workplace, with friends, and in intimate relationships.
5. Wymbs et al. (2015) showed that having intimate partners of young adults with ADHD involved in treatment was helpful in terms of improving the social skills of the individual with ADHD and reducing interpersonal conflict in the relationship. In this study, the partner assumed a helping role. Couples' therapy that targets resolving problems in intimate partner relationships may be helpful for older adults. Research should examine whether this type of treatment would lower the high rates of separation and divorce among adults with ADHD (Wymbs, 2021).

20.5 Conclusion

Although most of the research on social relationships of individuals with ADHD has been done with children, there is sufficient research with adults to conclude that it is a lifelong impairment. At least 50% of children with ADHD are rejected by peers (Hoza, 2007). Children and adolescents with ADHD have difficulty developing and maintaining high-quality friendships, and they are much more likely to be victims and perpetrators of bullying than their typically developing counterparts. Older adolescents and adults struggle with maintaining quality intimate partner relationships, and they are more likely to be victims and perpetrators of intimate partner violence. Adults with ADHD also report challenges with relationships with co-workers. Conflict with others is a key issue. As most of the research is correlational, it is not possible to identify the causes of their problems.

Nevertheless, it is reasonable to conclude that there are multiple correlates of their social relationship difficulties: their ADHD symptoms are annoying to peers; they have inadequately developed social skills; they have problems with social perspective taking; and they may not perform positive social behaviors due to emotion dysregulation. Among individuals with ADHD, oppositional behaviors exacerbate their social relationship difficulties.

Children, adolescents, and adults with ADHD report that they experience considerable distress as a result of their social relationship difficulties. Their problems with social relationships are associated with anxiety and depression (Becker et al., 2012; Humphreys et al., 2013; Meza et al., 2016; Simmons & Antshel., 2021). However, with the exception of SST interventions for children and young adolescents, interventions for individuals with ADHD typically focus on the reduction of ADHD symptoms, enhancing organization, time management, and planning skills, and treating co-occurring mental health problems. This review of the research suggests that the focus of treatment should be on developing positive social skills, behaviors, and relationships in childhood, adolescence, and adulthood.

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21 Group Parent–Child ADHD Treatments

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Children with attention-deficit/hyperactivity disorder (ADHD) endure more functional impairment in a variety of domains than their typically developing peers. In particular, they experience long-term adverse academic achievement/performance (Arnold et al., 2020), demonstrate earlier signs of delinquency (Sibley et al., 2011), social and peer problems (Fogleman et al., 2019), and more behavioral and emotional difficulties (Barkley, 2015) that have been linked to poorer outcomes in adulthood (Barkley, 2008). Evidence-based psychosocial interventions for ADHD can help alleviate ADHD-related impairments such as organizational skills deficits and time management (Bikic et al., 2021), social difficulties (Storebø et al., 2019), emotion regulation (Vacher et al., 2020), and family conflict/parenting stress (Ciesielski et al., 2019).

While central nervous system (CNS) stimulant medication is typically the first-line treatment for individuals with ADHD, there are circumstances in which psychosocial interventions need to be used primarily or in conjunction with pharmacological treatments. CNS medications are extremely effective in short-term improvements targeting the core symptoms of ADHD (i.e., inattention, hyperactivity, and impulsivity), but there are limitations to the utility and effectiveness of these medications. Limitations include (1) many parents/guardians prefer not to use pharmacological interventions due to potential side effects (e.g., insomnia, appetite suppression), (2) approximately 20–30% of children do not respond to medication with minimal or tolerable side effects, (3) medication alone does not minimize difficulties sufficiently in severe cases, (4) medication does not result in long-term change, (5) medication compliance is often poor such that 30–80% of children stop taking it prematurely and (6) medication has limited impact on symptoms of mood and anxiety in children with ADHD who have comorbidities (Adler et al., 2019; Baweja et al., 2018; Pelham Jr. & Fabiano, 2008; Spencer et al., 1996). Thus, non-medication treatments can be used to address these limitations. In particular, non-medication treatments serve to improve long-term functioning rather than just acute problems by teaching specific skills and techniques to both the child and parents. Instead of purely targeting the core symptoms, psychosocial treatments aim to improve other ADHD-related difficulties such as social skills, parent–child relationships/family functioning, and reactivity.

21.1 Behavioral Treatments

Substantial research has evaluated the use of behavioral treatments for children and

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adolescents with ADHD. Behavioral treatments incorporate social learning and operant conditioning principles to modify children's behavior. These theories suggest that manipulating the antecedent and/or consequence of a child's behavior will increase desirable behaviors and prevent and/or diminish undesirable behaviors. For example, antecedent-based strategies such as stimulus control manipulate contextual factors that precede the child's behavior (Antshel & Barkley, 2008). A parent who gives specific and clear directions may elicit increased desirable behaviors (i.e., compliance) as the child is able to encode, attend to, and understand what is expected of them. Conversely, a parent who gives multi-step or vague directions may elicit increased undesirable behaviors (i.e., noncompliance) as the child may have greater difficulty attending to, encoding, and following through with these instructions. With consequent-based strategies or contingency management techniques, parents establish expectations for their child by either rewarding, punishing, or ignoring the child's behavior (i.e., contingency management; Bandura, 1977; Thompson, 2013), which provides immediate feedback regarding the appropriateness of the child's behavior. A child who receives praise for putting away their toys may be more likely to clean up in the future – the parent's positive attention reinforces the child's behavior as they learn that something enjoyable (i.e., praise) is associated with cleaning. A parent who ignores a child's tantrum in response to not getting a toy they want communicates to the child that these behaviors are not appropriate to reach their goal.

Behavioral treatments aim to modify children's behaviors by establishing clear and consistent expectations and controlling how reinforcement and consequences are applied within the child's environment (Chacko et al., 2008; Fabiano et al., 2009; Owens et al., 2017). Caregivers (e.g., clinicians, parents, teachers) track how specific child behaviors change in response to these modifications, assessed via the rate, frequency, and intensity of the targeted behaviors. A variety of behaviors may be targeted for youth with ADHD such as compliance, on-task behaviors, completion of tasks/assignments, and organization. Researchers have developed behavioral management interventions for parents (behavioral parent training; BPT), the classroom (behavioral classroom management; BCM), and social settings (behavioral peer interventions; BPI: Evans et al., 2017; Pelham Jr. & Fabiano, 2008). Given the aim of this chapter, the following sections will discuss BPT and BPI more in detail.

21.1.1 Behavioral Parent Training

BPT is considered a gold-standard treatment for children and adolescents with ADHD and is often recommended in conjunction with stimulant medication (APA, 2013; Barkley, 2015). BPT programs train parents in the use of effective stimulus control and contingency management techniques to manage child behavior (Fabiano et al., 2015). Parents learn to identify and monitor problematic behaviors, manipulate the antecedents and consequences of those behaviors, reward prosocial and/or desirable behaviors, and ignore and/or punish undesirable behaviors (Chronis et al., 2004). During the early stages of treatment, parents are provided psychoeducation on ADHD to help parents understand their child's strengths and deficits and establish appropriate expectations and are taught to monitor and record their child's behavior. These records are used to identify base rates of target behaviors that will be modified over the course of treatment using antecedent-based and consequent-based strategies. Antecedent-based strategies include establishing clear expectations and using effective commands (Kazdin, 2010; Chronis et al., 2004; Pelham & Gnagy, 1999). Parents brainstorm and discuss developmentally appropriate expectations for their children and learn how to communicate these expectations effectively. For example, parents may establish an expectation to be respectful and provide their children with examples of what respect looks like for their family. To facilitate child compliance, parents learn and practice how to give concise and direct commands (e.g., "Put your shoes in your room" vs. "Put your stuff away").

Treatment Components and Techniques Consequent-based strategies include point/token systems, positive attending and planned ignoring, loss of privileges, and time-out. Parents learn to implement reward systems in which children can earn privileges by meeting behavioral or household expectations. For example, a child who completes their morning routine without prompting may earn extra television time. By providing a tangible reward for the target behavior, the parent reinforces the action and provides an incentive for the child to continue to meet the behavioral expectation, which increases the probability that the behavior will continue in the future. Another strategy to increase desirable behavior is the use of positive attending. Positive attending occurs when parents praise and positively reinforce the child for acceptable or desirable behaviors. For example, a parent might state "You did a great job putting your toys away in the box" after their child cleans up. This confirms to the child that they put their toys in the correct spot while also providing positive reinforcement to increase the likelihood that the positive behavior will be repeated in the future. Conversely, parents also learn to effectively use planned ignoring. Planned ignoring occurs when parents do not interact with their children while they are engaged in undesirable behavior. A parent who does not react or respond when a child is whining communicates to the child that this is not an effective or acceptable way of achieving their goal. Planned ignoring serves to diminish undesirable behaviors by removing any positive reinforcers (i.e., attention) that would encourage the continuation of the child's behavior. If a child is engaged in destructive and/or dangerous behaviors, parents also learn to use effective time-outs to address these behaviors. Effective time-outs involve an immediate response and removal of the child from positive reinforcers. Parents learn to provide explanations to the child for the time-out and establish clear expectations for how this time will be spent. Additionally, parents learn to provide praise and positive reinforcement if the child completes the time-out without conflict.

Antecedent-based strategies and stimulus-control techniques include effective commands and structure. Effective commands are clear instructions that clarify what behavior is expected of a child in a specific situation (Staff et al., 2022). Effective commands should be positively stated, specific, simple, and direct. For example, "go clean your room," may be too general of a command; therefore, "please put your dirty clothes in the basket," is a more specific and simple command which may increase child compliance. Adding structure may look like setting and reminding a child of clear expectations at dinner about the child's behavior and removing toys and other distractions to make it easier for the child to stay seated during dinner (Hornstra et al., 2021). These antecedent-based techniques aim at changing behaviors by manipulating the surrounding conditions to increase the chance that a child performs the desired behavior and prevent undesirable behaviors. These strategies aim to strengthen the relation between the stimulus condition and the response (i.e., child behavior; Staff et al., 2022).

BPT programs can be conducted in individual or group formats and typically range between 8 and 12 sessions (Chacko et al., 2009; Pelham Jr. & Fabiano, 2008). While individual formats can allow for tailored approaches to the family's needs, group formats are often more cost-efficient and provide social support and collaboration for families of youth with challenging behaviors (Chacko et al., 2009; Evans et al., 2017; Fabiano et al., 2015; McKay et al., 2011; Webster-Stratton, 1984). Group BPT typically occurs in weekly 2–2.5 hour sessions that incorporate both didactic and collaborative content (Chacko et al., 2009; Chronis et al., 2004; Pelham Jr. & Fabiano, 2008). Clinicians provide psychoeducation on ADHD and antecedent-based and consequent-based behavior management strategies. Parents are encouraged to share their ideas, collaborate on treatment goals for their children, and participate in role-plays to enhance skill development.

21.2 Evaluating Components

Given concerns regarding the applicability and utility of BPT programs in outpatient and community care settings, studies have evaluated whether certain components of BPT are sufficient to address child ADHD and associated concerns. Dekkers et al. (2022) found that antecedent-focused strategies were associated with increased parental self-efficacy and parental mental health and consequent-based strategies were associated with decreased negative parenting. However, higher doses of psychoeducation were negatively associated with positive parenting and the quality of parent–child relationships (Dekkers et al., 2022), suggesting that psychoeducation may not provide particular benefits for parenting skills and parent–child interactions. Another study found that both antecedent-based and consequent-based strategies were effective in decreasing daily behavior problems, with clinically significant change maintained for up to 3 months post-treatment (Hornstra et al., 2021). However, these authors found that antecedent-based strategies were associated with an immediate reduction in daily behavior problems, whereas consequent-based strategies were not effective until several weeks into treatment (Hornstra et al., 2021). As consequent-based strategies require consistent and repeated exposure to behavioral consequences before the child begins to change their behavior, these strategies may take longer to take effect before producing clinically meaningful and significant change (Owen et al., 2012).

21.3 Effectiveness and Efficacy

Substantial research has evaluated the use of BPT programs for parents of youth with ADHD. Results from systematic reviews and meta-analyses consistently support the efficacy of BPT in reducing ADHD symptoms and improving parenting skills (Charach & Fernandez, 2013; Fabiano et al., 2015; Lee et al., 2012; Pelham Jr. & Fabiano, 2008). Indeed, ADHD symptoms and behavioral problems (e.g., oppositionality) typically decrease immediately following BPT (Anastopoulos et al., 1993; Bor et al., 2002; Pisterman et al., 1992; Sonuga-Barke et al., 2002). Furthermore, BPT is associated with improvements in family functioning, such that parents feel more competent in managing child behavioral problems, utilize more positive parenting skills, and decrease the use of negative or harsh parenting (Daley-McCoy et al., 2015). Data from one meta-analysis suggest that BPT programs are more efficacious than waitlists, non-directive parent counseling and support, and no-treatment control groups, with effect sizes ranging from 0.47 to 0.70 (Pelham Jr. & Fabiano, 2008).

These efficacy studies demonstrate the benefits of BPT under ideal and controlled settings. However, given concerns with the adaptation of highly controlled treatments in real-world clinical settings, the evaluation of effectiveness studies is imperative (Rosqvist et al., 2011). Data from one study evaluating the effectiveness of BPT indicate that BPT + routine clinical care decreases behavioral and internalizing problems in children with ADHD (van den Hoofdakker et al., 2007). However, BPT + routine clinical care did not significantly reduce ADHD symptoms or parenting stress compared to routine clinical care alone (van den Hoofdakker et al., 2007). Importantly, the authors note that children in the routine clinical care only group received more pharmacological treatment compared to the children in the BPT + routine clinical care group (van den Hoofdakker et al., 2007); thus, the effect of medication cannot be ignored when interpreting these results. Another study evaluated the effectiveness of BPT for parents of preschoolers with ADHD within an outpatient clinic (Risley et al., 2020). The authors found medium to large effect sizes for academic progress, severity of non-compliance, ADHD symptom ratings, overall severity of impairment, and parental confidence ratings (Risley et al., 2020). Small effect sizes emerged for reduced impairment in family functioning, self-esteem, peer and parental relationships, oppositionality, and frequency of non-compliance (Risley et al., 2020). Other effectiveness studies have found positive treatment outcomes for child impairment, child compliance, parenting behaviors, parenting confidence, and parental stress (Loren et al., 2017; van den Hoofdakker et al., 2010). These data provide preliminary support for the use of BPT in real-world settings; however, additional research is needed to evaluate the effectiveness in other community samples.

21.4 Factors Impacting Treatment Outcomes

In addition to examining unique treatment components contributing to clinical outcomes, research has also investigated the contribution of parent, child, and contextual factors. For example, parental self-efficacy (the parent's belief in their capabilities to raise their child) influences treatment outcomes, such that higher levels of parental self-efficacy played a moderating role in decreasing behavior problems following BPT and routine clinical care (Johnston et al., 2010; van den Hoofdakker et al., 2014). Parental psychopathology has also been identified as an influential factor in treatment outcomes. Discrepant results for maternal and paternal ADHD symptoms have emerged, such that higher levels of maternal ADHD symptoms were associated with lower treatment benefits (Sonuga-Barke et al., 2002), whereas paternal ADHD symptoms were associated with increased treatment benefits (van den Hoofdakker et al., 2014). Additionally, higher levels of maternal depressive symptoms and higher levels of parenting stress have been associated with worse treatment outcomes following BPT (Chronis et al., 2004; Kazdin et al., 1997; Webster-Stratton, 1984). It is likely that parenting stress and depressive symptoms make it harder to implement consistent parenting behaviors and interfere with motivation to fully engage in BPT programs (Chronis et al., 2004).

Child characteristics, such as comorbid internalizing or externalizing disorders, also influence treatment outcomes. Van den Hoofdakker et al. (2010) found that children with one or fewer comorbidities responded more favorably to BPT + routine clinical care compared to routine clinical care alone. Conversely, children with multiple comorbidities responded equivalently to BPT + routine clinical care and routine clinical care alone (van den Hoofdakker et al., 2010). Jensen et al. (2001) also found that the presence of comorbidities was associated with overall worse short-term treatment outcomes for BPT, especially with comorbid anxiety disorders. Baseline severity of ADHD symptoms and other behavioral problems also predict treatment outcomes, such that higher symptom severity levels are associated with poorer treatment outcomes compared to lower symptom severity levels (Lee et al., 2012; Lundahl et al., 2006; Reyno & McGrath, 2006).

BPT also requires significant investments of time and money, which may not be feasible for all families (Pelham et al., 2000). Other relevant contextual factors include single-parent status, perceived social support, and socioeconomic status (Cairney et al., 2003; Schneider et al., 2013). Systematic reviews have suggested that between 26% and 51% of parents drop out of BPT programs (Chacko et al., 2016), which is partially attributed to single-parent status and socioeconomic status (Chacko et al., 2016; Schneider et al., 2013). Single parents experience higher rates of stress and less social support which likely makes it difficult for these parents to follow through with the increased demands that treatment places upon them. Families with lower socioeconomic status may be more likely to drop out due to the lack of financial resources to afford the treatment itself, transportation, and possible childcare expenses (Cairney et al., 2003; Schneider et al., 2013).

21.5 Adaptations and Modifications

While BPT programs have exhibited success in reducing ADHD symptoms and related impairments, concerns regarding parental engagement and maintenance of treatment effects have prompted researchers to explore modifications to BPT to increase applicability and generalizability. For example, some programs have targeted parental engagement by enhancing their intake procedures to address practical barriers, treatment expectations, and parental motivation for treatment (Chacko et al., 2009). Other programs have targeted the treatment modality (e.g., telephone, in-person, virtual) to increase treatment accessibility. Results from a study comparing treatment-as-usual to a phone-delivered BPT program found that the BPT group exhibited significantly fewer ADHD symptoms and related impairments following treatment, with benefits sustained for one year (McGrath et al., 2011). Variations of BPT have also been developed to address behavioral concerns at different developmental stages, such as Parent–Child Interaction Therapy (PCTI; Eyberg et al., 2001) for young children or Defiant Teens (Barkley & Robin, 2014) for adolescents. Please see Table 21.1 for examples of BPT programs.

The majority of research evaluating BPT has been conducted with white, middle- to upper-class families (Henrich et al., 2010). However, given that BPT primarily targets parenting practice and parenting is an inherently culture-bound process (Bornstein, 2012), cultural considerations are imperative when evaluating BPT programs. Parents may be more likely to drop out or discontinue BPT programs if the training is in conflict with their cultural beliefs (Kazdin et al., 1997; Kendall & Sugarman, 1997; Shirk, 2004). A systematic review of cultural adaptations for behavioral parent training found that the most common methods to develop adaptations were conducting interviews with community members and building partnerships within the community to determine needs and appropriate strategies (Butler et al., 2015). Two examples of culturally adapted BPT programs are reviewed below.

Malik et al. (2016) reported several cultural differences between Pakistani and American families following the use of BPT. Pakistani families had increased reliance on extended family members for child-rearing, and an increased societal emphasis on obedience, discipline, respect for elders, and self-control (Malik et al., 2016). Furthermore, differences in the acceptability of praise and rewards emerged. Specifically, Pakistani parents experienced difficulties understanding and implementing reward systems and attendance rates dropped from 83% to 60% following the introduction of reward systems (Malik et al., 2016). Other adaptations included increased contact with extended family members, reframing BPT as a parent education program (versus a treatment program), and increased emphasis on psychoeducation and mental health awareness. Results suggested that the BPT group showed significant post-treatment improvement in behavioral problems and ADHD-related impairment compared to the waitlist control (Malik et al., 2016).

Gerdes et al. (2015) conducted a small pilot study evaluating culturally adapted parent training for Latino youth with ADHD. Focus groups were conducted with Latino parents to determine necessary cultural adaptations and general beliefs regarding parent training. Following the focus groups, the researchers made global adaptations to treatment materials and session content, such as including more role plays demonstrating parenting skills, coaching of parents during the session, simplified handouts with examples and comic strips to portray the skills, and video demonstrations that parents could view at home. Gerdes et al. (2015) also addressed cultural differences regarding treatment terminology and parenting expectations by changing the use of the word “problems” to “concerns” or “challenges,” explaining to parents that change takes time, emphasizing the importance of homework completion, and involving the extended family when working with Latino families. Finally, the researchers adjusted logistical aspects such as the cost and time of treatment sessions. The adaptations were evaluated with a small sample ($N = 5$) of Latino parents of children with ADHD. Results suggested that all families were highly satisfied with a treatment, and positive outcomes were observed for ADHD symptoms, parenting, and family functioning (Gerdes et al., 2015).

Table 21.1 Examples of behavioral parent training (BPT) programs and adaptations

Article	Program	Treatment format	Age range	Treatment features
Eyberg et al. (2001)	Parent–Child Interaction Therapy (PCIT)	Individual Completion of treatment determined by parental mastery of skills	Ages 3–6 years old	Child-directed interaction (CDI) focuses on developing warm and responsive parent–child relationships Parent-directed interaction (PDI) teaches parents to monitor and apply consistent consequences to child behavior problems Direct observations of parent–child interactions and real-time coaching of parenting practices
Webster-Stratton and Reid (2011)	Incredible Years	Groups, individual Weekly 2-hour sessions, ranging from 10 to 24 sessions	Ages 0–12 years	Strategies to promote parent–child interactions, reduce harsh discipline, and facilitate parents' ability to enhance children's social, language, and emotional development Emphasizes parental interpersonal skills to facilitate effective communication Active skills training (e.g., video modeling, role play, practice activities, live feedback)
Sanders (2012)	Triple P Positive Parenting Program	Group, individual 10 weekly 1-hour sessions	Ages 0–17	Child management strategies to enhance children's competence and development and manage child misbehavior Parents receive training for planning activities and maintaining household routines Active skills training (e.g., modeling, role plays, feedback, homework)
Chacko et al. (2009)	Strategies to Enhance Positive Parenting (STEPP)	Group 9 weekly 2.5 -hour sessions	Ages 5–12 years	Focus on enhancing parent training for single mothers Active skills training (e.g., videotaped vignettes, group discussions, modeling, and role-play scenarios) Enhanced intake procedure to improve treatment motivation and engagement, address practical barriers, and explore treatment expectations Incorporated coping-modeling, problem-solving format to increase parental participation and improve social support between mothers
McGrath et al. (2011)	Strongest Families	Individual 12 weekly 40-minute sessions	Ages 8–12 years	Telephone application of BPT Session agendas included skill review, skill modeling with role-playing and verbal examples, problem-solving, and skill implementation Parents learn positive parenting strategies (e.g., positive attending, reward systems, effective discipline)

(continued)

Table 21.1 (continued)

Article	Program	Treatment format	Age range	Treatment features
Fabiano et al. (2012)	Coaching Our Acting-Out Children: Heightening Essential Skills (COACHES)	Group Weekly, 2-hour sessions	Ages 6–12	Focus on enhancing parent training for fathers Fathers learn effective parenting and problem-solving strategies, and practice implementing these strategies during a parent–child recreational activity (e.g., soccer game) Review videotapes, identify parenting errors, and generate new solutions

21.6 Behavioral Peer Interventions (BPI)

Many children with ADHD have deficient social skills and difficulty in peer relationships. Behavioral peer interventions (BPI) utilize contingency management to improve children's peer relations. Traditional BPIs, such as social skills training (SST) groups, are typically weekly and clinic-based programs. However, research suggests that these interventions are not very efficacious when used as the only form of treatment (Pelham Jr. & Fabiano, 2008), potentially because it is difficult to enhance peer relations in an office environment. One of the most common and well-established BPIs for children with ADHD is the summer treatment program (STP), which combines parent training, social skills training, and academic instruction with a contingency management system in a summer day-camp environment (Pelham Jr. & Fabiano, 2008). The STP was developed taking a social-learning approach to ADHD, emphasizing the importance of modeling, observing, and motivation as a way to increase desired behaviors while decreasing the recurrence of undesired behaviors in children (Fabiano et al., 2014).

21.6.1 Summer Treatment Program

The STP was initially established as an intensive and comprehensive alternative to typical BPIs to target three domains of impairment that are common in children with ADHD: peer relations, parent–child relations, and academic functioning (Pelham Jr. et al., 2005). Instead of weekly group sessions in an office setting, the STP is a 5-day-a-week, 8–9 hours per day program that is conducted for 6–8 weeks over the summer. The STP was developed to combat three main restrictions of typical BPIs that limited benefits for children with ADHD. First, as previously mentioned, it is difficult to teach children skills to improve peer/social functioning in an office setting that is dissimilar to environments where they would be interacting with peers in their daily lives. Instead, STP is conducted in a day camp setting that mimics real-world peer interactions in social, academic, and interpersonal environments. Second, ADHD has a high comorbidity rate with learning disorders/difficulties, but neither traditional BPIs nor medication has been shown to produce lasting change with these issues (Loe & Feldman, 2007). Evidence has shown that long breaks from school (e.g., summer break) can lead to the loss of academic skills in children who have learning difficulties (Borman & Boulay, 2004). To combat this phenomenon, the STP includes academic instruction in a classroom setting for a portion of each camp day. Third, it is common for parents of children with ADHD to have strained parent-child relations and inadequate parent management strategies. The STP includes weekly evening parent training workshops to supplement the intensive training done with the children during the day.

Treatment Components and Techniques Children are placed into groups of 12–16 peers based on their age and stay with their group for all activities throughout the summer. Each group is run by 4–5 counselors, who are typically college students. All counselors go through rigorous training weeks prior to the children's arrival in which they learn the strategies outlined in the STP manual and must "test out" using the point and contingency management systems. Daily activities for each group include group discussions, instruction in appropriate hallway transitions, and classroom instruction, as well as typical day-camp activities such as sports games, art, lunch, and recess.

Social Reinforcement, Praise, and Effective Commands All staff members and counselors use social reinforcement and praise to encourage the children to repeat appropriate and desired behaviors when they occur (Martin & Pear, 2019). For instance, if a child is sitting quietly listening to the group discussion, a counselor could praise the child by saying "[Child's name], I love how quietly you are sitting!" The positive and public recognition will motivate the child to continue exhibiting that behavior. Another way counselors encourage appropriate behavior is using effective commands that minimize ambiguity/the likelihood the child will disobey. This includes being brief and specific with directions and using positive phrasing. For example, instead of saying "Be patient," which is vague and could be interpreted differently, a counselor would say "Stand quietly in line until the group is ready to leave" (Fabiano et al., 2014).

Point System The STP uses a "systematic reward-response cost program" (also known as a "token economy" or "point system") in which children have the opportunity to earn points for exhibiting a set list of common positive/appropriate behaviors and lose points for exhibiting a set list of common negative/inappropriate behaviors (Fabiano et al., 2014). Token systems like this are well-established techniques proven to alter children's behavior (Kazdin & Bootzin, 1972). Children learn the point system on the first day of camp through a group discussion in which the counselors explain and give examples of what behaviors are inappropriate and appropriate, as well as the number of points they can earn/lose for each behavior. The behaviors included in the point system were designed to specifically target behaviors that are difficult for kids with ADHD (e.g., following the rules, staying on task, and positive sportsmanship). Points are continuously tracked all day by the counselors and announced publicly as soon as the behavior occurs. For example, if Child A teases Child B, a counselor would immediately say "Child A, you lose 50 points for *Name Calling/Teasing*" and "Child B, you earn 25 points for *Ignoring a Negative Stimulus*." At the end of each week, children are able to use their acquired points to receive prizes.

Daily Report Card In addition to earning points, children are incentivized to behave appropriately through Daily Report Cards (DRCs), a well-established behavior modification technique (Lahey et al., 1977). Each week children are individually assigned a few behavioral goals to target specific difficulties they are having (e.g., Interrupting less than 10 times per day). At the beginning of camp, parents establish a home-based reward system based on whether their child meets their daily goals such that the child receives a positive consequence for accomplishing goals (e.g., extra television time, special activity with a parent). Parents must establish both a daily reward for if the child meets daily goals and a weekly reward for if the child meets their goals for the week. At the end of each camp day, a counselor meets briefly with each parent to discuss the child's DRC for that day and model to the parent how to respond to the child's performance. Parents are also encouraged to establish a home-based DRC to track the child's behaviors at home. DRCs help establish a link between behavior across settings for children.

Time-Out Procedures While children are disciplined for any and all negative behaviors via the point system, there are certain negative behaviors that are disciplined using an exclusionary "time out from positive reinforcement" Procedure. The STP time-out procedures include having the child sit alone in a specified area next to where their group is engaging in their activity. The base of the time-out time is determined by the child's age, but a "telescoping time-out" procedure is used for all age groups whereby children have the opportunity to earn time off their time-out time for behaving appropriately during the time-out but will have the length of the time-out escalated if they refuse to comply with time-out procedures or continue to exhibit negative behaviors during time-out. Behaviors that result in a time-out include intentional aggression, intentional destruction of property, and repeated non-compliance.

Sports Training Children with ADHD often struggle with learning and following game rules, as well as exhibiting good sportsmanship. These difficulties can lead to poor self-esteem and peer rejection (Pelham & Milich, 1984). Thus, the STP incorporates recreational sports throughout each day to help build children's knowledge and familiarity with different sports and help children generalize learned positive behavior to sports settings. This includes both skills training for each sport and full practice games coached by counselors. Children are repeatedly asked questions about the rules throughout the game to solidify their knowledge and to keep their focus on the current task. For example, after announcing the current score of the game, a counselor could ask a child "What is the score of the game?" or "Which team is in the lead?"

Peer and Social Skills Children are taught different social skills throughout the camp through group discussions, role plays, and in vivo practice during the camp day. Prosocial skills that are commonly deficient in children with ADHD are targeted (e.g., communication, giving compliments, cooperation). Counselors engage in social skills training with their group at the beginning of each camp day. This typically includes introducing and defining a specific skill and then practicing the skill by modeling it for the children and then having the children participate in role playing the skill. The social skill discussed each morning is then reviewed during the group discussion prior to each recreational activity.

Academic Instruction Children spend a portion of each day in a classroom environment and participating in academic work. Children receive assignments in typical school subjects (e.g., mathematics, reading, vocabulary, art) that match their current academic level. The point system is altered slightly to keep the focus on the work assignments. More specifically, children enter the classroom with a certain number of points, lose points for violating the rules of the classroom (e.g., leaving a seat without permission), and earn points for completing tasks and work accuracy.

21.6.1.1 Evaluating Components

Although each component of the STP was included due to being a well-established strategy for managing children's behavior, it is important to evaluate the effectiveness of each component as a part of the STP. Researchers compared the outcomes of children with ADHD who were given no behavior modifications, a low level of behavior modification (i.e., classroom rules during academic instruction, point system, time-out procedures, and social reinforcement/praise), and a high level of behavior modification (i.e., classroom rules during academic instruction, point system, time-out procedures, social reinforcement/praise, DRCs, individualized behavioral goals). They found that both low and high levels of behavior modification led to more significant improvements in behavior and academic work than not including behavior modification strategies (Fabiano et al., 2007). This suggests that the behavioral modification strategies used in STP are beneficial components of treatment. In addition, Fabiano et al. (2004) found that including time-out procedures in STP leads to significantly fewer instances of physical aggression and non-compliance at the completion of treatment. This suggests that the time-out procedures add incremental benefits to the treatment overall.

21.6.1.2 Effectiveness and Efficacy

There have been a plethora of studies evaluating the clinical outcomes of STP. Researchers have found STP to be both efficacious and effective when compared to a no-treatment condition (Chronis et al., 2004; Coles et al., 2005; Fabiano et al., 2007). STP was effective for both boys and girls 5–12 years old regardless of age, comorbidity status, family characteristics, or medication regimen. Studies suggest that STP improves parent satisfaction with children's behavior, classroom behavior/performance, peer functioning, sports knowledge/performance, and gross-motor skills (Fabiano et al., 2007; O'Connor et al., 2013; Pelham & Hoza, 1996). Chronis et al. (2004) examined the effects of treatment withdrawal on children who completed STP. The treatment withdrawal design removes all behavioral treatment components of STP in week 6 of treatment for 2 days. After these 2 days, the behavioral treatment components are reinstated. They found that children's behavior deteriorated during the withdrawal period but returned back to previous levels once the behavioral treatment components were reinstated. These results held regardless of whether children were simultaneously taking stimulant medication. This suggests that STP is effective in addressing impairment across multiple settings (e.g., classroom, peer relationships).

21.6.1.3 Factors Impacting Treatment Outcomes

Sidol and Epstein (2020) conducted a review examining potential moderators of STP outcomes. They found that ADHD presentation (i.e., ADHD/combined, ADHD/inattentive, and ADHD/hyperactive-impulsive) may be a moderator of STP outcome such that children with higher levels of hyperactive-impulsive symptoms exhibited greater improvements in school performance, classroom functioning, home behavior, and peer functioning than children with fewer hyperactive-impulsive symptoms. Their review did not find that age or comorbidity status impacted treatment outcomes.

21.6.1.4 Cultural Adaptations

Yamashita et al. (2011) examined the effectiveness of STP in children with ADHD in Japan and found that both cognitive and behavioral functioning improved. Researchers modified the typical 8-week STP program to be a shorter program due to the shorter summer break in Japan (only 6 weeks). Researchers conducted both a 2-week program and 3-week program between the summers of 2005–2009 and found that there was significant improvement after 2 weeks but that an additional week did not make a difference. However, to the authors' knowledge, no cultural adaptations have been made to STP and this is a gap in the literature. More research is needed to examine if and how STP can be effective for children of varying cultures.

21.6.1.5 Adaptations and Modifications

Researchers have made adaptations to STP for both preschoolers and adolescents. These adaptations focused on the developmental differences that both preschoolers and adolescents, respectively, experience in comparison to 6- to 12-year-old children, such as differences in self-regulation, independence, and academic, social, and vocational demands. The preschool program (STP-Pre-K; Graziano et al., 2014) aims to target preschoolers at high risk of developing severe behavioral disorders and improve school readiness at an early age. STP-Pre-K added a comprehensive school readiness curriculum and a social-emotional curriculum to improve the children's self-regulation skills. The school readiness curriculum reinforced state standards for reading, English/language arts, math, and science for entering kindergarteners using portions of the evidence-based *Literacy Express Preschool Curriculum.* The social-emotional curriculum consisted of social skills and emotional awareness training through the use of puppets, in vivo training, and reinforcement of the skills. Four social skills (participation, communication, cooperation, encouragement) and eight emotional states (happy, sad, mad, scared, surprised, disgusted, embarrassed, guilty) were targeted in the curriculum. Parents/

guardians were required to attend a specific parenting training (School Readiness Parenting Program [SRPP]; Graziano & Derefinko, 2013) that was developed from content from PCIT. The researchers found that several domains of school readiness (behavioral, academic, and self-regulation) significantly improved after the intervention (Graziano et al., 2014).

The adolescent program (STP-A; Sibley et al., 2011) includes developmentally appropriate modules for middle and high school students such as substance use prevention, job management, romantic relationships, and difficult social/interpersonal interactions. STP-A also included academic modules to help develop skills in critical listening, summary writing, note-taking, studying, partner work, quiz-taking, planning, intensive writing, and organization. The vocational module aimed to develop planning skills, teamwork, responsibility, and money management skills in a Future Business Leaders of America (FBLA)-style program. The social skills modules consisted of small group sports scrimmages where adolescents practiced social skills, leadership skills, and problem-solving. Sibley et al. (2011) found that adolescents showed improvement in several domains (conduct problems, adult-directed defiance, social functioning, inattention/disorganization, mood/well-being, and academic skills).

21.7 Parenting Treatments

In addition to BPT, there are other evidence-based parent-focused treatments for children with ADHD. Parents/guardians play an important role in treating children with ADHD. Parents are often able to manage and alter their child's environment, which can allow them to reduce potential triggers for their child's negative behavior. Parent-focused treatments are built on the premise that if parents are able to learn to deliver treatment techniques at home, then the treatment effects will be maintained (Funderburk & Eyberg, 2011).

21.8 Non-specific Treatments Used for ADHD

There are other evidence-based treatments that work for children with ADHD, but that were not specifically developed for ADHD. Some of these treatments target younger children, who might exhibit ADHD symptomology but are too young to meet the criteria for a full diagnosis (e.g., 3-to-5 years old). In addition, these treatments might serve as a preemptive intervention for children who are showing early behavioral issues. Because many of these treatments were developed for younger children, they primarily focus on parenting practices and parent–child interactions.

21.8.1 Parent–Child Interaction Therapy

Parent–Child Interaction Therapy (PCIT) is an evidence-based treatment that was originally developed in the late 1970s for young children (i.e., ages 2–7) diagnosed with a disruptive behavior disorder (Eyberg & Matarazzo, 1980; Eyberg & Robinson, 1982; Funderburk & Eyberg, 2011). While the structure of PCIT was created using play and behavior therapy, the unifying theory was derived from Baumrind's (1967) work on parenting styles and practices. This theory of parenting suggested that there are three parenting styles (i.e., permissive, authoritarian, and authoritative) in which parents vary in terms of their responsiveness and demandingness. A large body of literature suggests that the authoritative parenting style, which involves a parent being demanding, responsive, and warm, results in healthy academic, social, and emotional development (Baumrind, 1991, 2012, 2013; Xiong et al., 2020). Even more, authoritative parenting is associated with fewer disruptive behaviors in children than other parenting styles (Querido et al., 2002). Thus, PCIT aims to train parents and caregivers in authoritative parenting by using principles of both social learning and attachment theory (Funderburk & Eyberg, 2011). PCIT is conducted using in vivo feedback (i.e., coaching), such that therapists watch as parents communicate with their children in real time and provide tips/skills at the moment to teach parents more beneficial ways to respond to the child (Barnett et al., 2017). This serves to improve future parent–child interactions.

21.8.1.1 Treatment Components and Techniques

PCIT is a time-unlimited treatment such that families receive services until such time as they can demonstrate mastery of skills and their child's disruptive behavior is occurring within normal limits of typically developing children (Eyberg & Funderburk, 2011). It combines Child–Directed Interaction (CDI) and Parent-Directed Interaction (PDI). The CDI phase of PCIT involves parents following the lead of their child. The goal of CDI sessions is to teach parents both how to effectively communicate with their child and how *not* to communicate with their child. One crucial communication skill that parents are taught to use during CDI is positive reinforcement The PDI phase of PCIT involves parents learning how to effectively give commands and consistently respond to their child's behavior (Eyberg & Funderburk, 2011). The goal of PDI sessions is to reduce the child's noncompliance and severe disruptive behaviors (e.g., destruction of property, physical violence; Eyberg & Funderburk, 2011). This is helpful for children with ADHD who struggle with impulsivity.

Child-Directed Interaction More specifically, parents are taught to use the behavioral therapy technique of positively reinforcing (e.g., via labeled praise, reflection, enjoyment, or behavior description) their child's appropriate behavior (Thomas & Zimmer-Gembeck, 2007), which has been shown to effectively alter behavior in children with ADHD. Conversely, parents are taught when to implement the technique of active ignoring. More specifically, therapists coach parents to actively ignore the child when the child engages in specific disruptive behaviors, and then positively attend to and reinforce the child once the child ceases engaging in disruptive behavior. Planned ignoring is commonly used with children who have ADHD because they often find any attention, even negative attention, reinforcing. Thus, if they engage in a behavior that is ignored (i.e., no eye, physical, or verbal contact), they are less likely to exhibit that behavior again.

Parent-Directed Interaction The PDI phase of PCIT involves parents learning how to effectively give commands and consistently respond to their child's behavior (Eyberg & Funderburk, 2011). Parents are taught to give simple commands (e.g., Please put on your coat) instead of multi-step commands (e.g., Please put your coat on, get your shoes, take the trash out) to increase the likelihood that their child will be able to follow through. This is helpful for children with ADHD so that their attention can focus on a clear and direct command. In addition to the positive reinforcement technique used in CDI, therapists train parents in giving their child a time-out if the child does not comply with the effective command they were given. Parents are trained to be consistent in how they respond to their child's behavior (Eyberg & Funderburk, 2011), which helps children with ADHD predict which behavior(s) will lead to negative consequences and which behavior(s) will result in positive consequences. Consistency in parental response is a crucial technique that therapists implement both to teach the child what negative consequences will occur after a negative behavior and to provide parents with a sense of control over their child's actions.

21.9 Evaluating Components

There are specific components of PCIT that might be particularly useful in targeting symptoms of ADHD relating to inattention and hyperactivity/impulsivity. The PRIDE skills taught during the CDI phase of PCIT are useful in helping with inattention. PRIDE is an acronym that refers to "Praise," "Reflect," "Imitate," "Describe," and "Enthusiasm." These are communication techniques that parents incorporate into their interactions with their children to promote positive behaviors and dissuade negative behaviors. For instance, parents are encouraged to praise a child when they exhibit positive behavior (e.g., "Thank you for sharing your toys with me") to increase the likelihood that they will repeat that behavior in the future. Research suggests that children with ADHD are more receptive to rewards than to punishment when seeking to change behavior (Humphreys & Lee, 2011). PRIDE skills emphasize the idea of "positive parenting," which is similar to another treatment, Positive Parenting Program (Triple P; Sanders, 2012) that has been found effective in treating ADHD in children (Bor et al., 2002). Positive parenting uses heightened reward responsivity to sustain children's attention and teach them to engage in behaviors that elicit a positive response from adults.

21.10 Treatments Showing Initial Feasibility

Gold-standard approaches such as BPT, BPI, and PCIT aim to decrease behavioral challenges and manage the core symptoms associated with ADHD (inattention, hyperactivity, and impulsivity) by establishing consistent expectations and reinforcements (Barkley, 2015; Comer et al., 2013; Kazdin, 2010). Although disruptive behaviors typically are reduced immediately following these interventions, longitudinal data suggest that the gold-standard treatments often do produce sustainable improvements (Hinshaw & Arnold, 2015; Lee et al., 2012; Molina et al., 2008). Furthermore, behavioral management programs such as BPT and PCIT often do not address other areas of impairment experienced by youth with ADHD, such as emotion regulation difficulties and peer challenges. Thirty to forty-five percent of youth with ADHD experience significant deficits in emotion regulation (Shaw et al., 2014) and struggle to identify and cope appropriately with strong negative emotions. Additionally, youth with ADHD often experience significant social challenges, including peer victimization and peer rejection (Fogleman et al., 2019). Despite these significant impairments in emotion regulation and social relationships, behavior management interventions often do not adequately address or target these difficulties (Fernandes et al., 2017; Hoza et al., 2005). To address these gaps in the ADHD treatment literature, researchers have proposed new treatment approaches that incorporate cognitive-behavioral, psychophysiological, and emotion-focused strategies. Examples of these treatments will be reviewed below.

21.10.1 Managing Frustration for Children

The Managing Frustration for Children (MFC) is a group treatment that targets emotion regulation difficulties for youth with ADHD (Rosen et al., 2019). In contrast to current gold-standard treatment approaches that primarily utilize behavioral principles to manage disruptive behaviors for children with ADHD, MFC incorporates behavioral, psychophysiological, and cognitive-behavioral strategies to address emotion regulation deficits. Over the course of 12 weekly group sessions, children learn problem-solving skills, learn to recognize physiological and cognitive cues of emotions, and develop coping skills to address immediate and future emotional distress (i.e., response-based and antecedent-based coping; Rosen et al., 2019). For example, children develop a "coping skills toolbox" that includes activities for immediate distraction or relief, such as listening to music, doing a breathing exercise, or talking to a friend. Other treatment strategies include teaching children to identify and challenge common thinking patterns that contribute to frustration and distress. Parents of children receive weekly updates regarding skills and content learned within the session as well as mid-treatment and post-treatment feedback.

Rosen et al. (2019) evaluated the MFC group program in an open trial of children with ADHD aged 9–11 years. The majority of participants (71.2%) had at least one comorbid internalizing, externalizing, or learning disorder. Results suggest significant decreases in mood difficulties, externalizing behaviors, and emotion regulation deficits post-treatment. Additionally, more than half of children who completed treatment exhibited clinically significant improvement in at least one area of functioning (e.g., peer, family, academic, self-esteem). Thus, initial data support the use of MFC as an emotion regulation treatment for youth with ADHD.

21.10.2 Supporting Caregivers of Children with ADHD

Supporting Caregivers of Children with ADHD is an integrated parenting program that teaches parents effective behavioral management strategies while simultaneously addressing parental emotion regulation and self-care (Chronis-Tuscano et al., 2020). While current gold-standard treatments for ADHD heavily emphasize behavioral management programs, they do not adequately address how parental stress and emotion dysregulation influences parenting behaviors and subsequent child reactions. Increased parental stress and emotion regulation difficulties predict adverse treatment outcomes for youth with ADHD and are associated with increased impaired parenting (Chronis et al., 2007; Chronis-Tuscano et al., 2010; Owens et al., 2003). Supporting Caregivers aims to address these concerns by incorporating cognitive, behavioral, and emotion-focused strategies to help both the parent and the child.

The Supporting Caregivers program is typically held over the course of 14 2-hour weekly group sessions. Group leaders provide psychoeducation and encourage skill practice via group discussions, modeling, role plays, and home exercises. Traditional behavior management training principles are incorporated, such as positive parenting, differential attending and planned ignoring, and establishing consistent expectations. Unlike other behavior management training, this program also integrates emotion-focused content. For example, parents learn how their own mood influences their parenting style and subsequent child reactions. Parents also learn how thoughts about their child (either positive or negative) influence their parenting and practice reframing negative thoughts about their child. Data from a randomized controlled trial comparing Supporting Caregivers and traditional BPT suggest that Supporting Caregivers offers notable benefits. Compared to BPT, Supporting Caregivers produced small to moderate effect sizes for parental depressive symptoms, negative parenting, child deviance, and child impairment at post-treatment (Chronis-Tuscano et al., 2013). At follow-up, small to moderate effect sizes were found for parental depressive symptoms, child disruptive behavior, child impairment, and family functioning (Chronis-Tuscano et al., 2013). Additional studies evaluating this intervention suggest that incorporating parental emotion-coaching strategies to address child emotion dysregulation also provides notable benefits (Chronis-Tuscano et al., 2016, 2020). Thus, Supporting Caregivers is a promising intervention to address common behavioral and emotional impairments experienced among families of children with ADHD.

21.10.3 Regulating Emotions Like an eXpert (RELAX)

More recently, Breaux and Langberg (2020) developed Regulating Emotions Like an eXpert (RELAX), a social-emotional intervention for adolescents with ADHD to target emotion dysregulation and interpersonal conflict. As noted above, current gold-standard treatments for ADHD do not adequately address emotion dysregulation deficits (Fernandes et al., 2017). Furthermore, treatments addressing emotion dysregulation deficits in adolescents (e.g., dialectical behavior therapy, emotion regulation training) are often not effective for adolescents with ADHD. RELAX aims to bridge this gap by incorporating cognitive, behavioral, interpersonal, and emotion-focused strategies for adolescents and their parents (Breaux & Langberg, 2020). RELAX is an 8-week group intervention that occurs weekly for 90 minutes (60-minute separate adolescent and parent sessions; 30-minute combined session). Session content aims to help the family recognize emotional triggers, increase emotional awareness and regulation of negative emotions, practice conflict management, and improve interpersonal communication (Breaux & Langberg, 2020). While both adolescents and parents learn similar content, RELAX provides parents with skills and content a week in advance of adolescents. In doing so, parents practice modeling the skills for the adolescents and work to incorporate them into their daily lives (Breaux & Langberg, 2020).

A pilot study with 18 adolescents and their caregivers suggested notable changes following RELAX. Large improvements were found in adolescent emotion dysregulation and family conflict (Breaux & Langberg, 2020). Additionally, large effect sizes were observed for parental supportive reactions to negative emotions and parental emotion dysregulation (Breaux & Langberg, 2020). Notably, similar effects were found when RELAX was delivered via telehealth, such that in-person and telehealth delivery of RELAX both resulted in decreased family conflict and improved adolescent and caregiver emotion regulation (Breaux et al., 2021) Thus, RELAX offers a promising and flexible avenue to address family conflict and emotion dysregulation for families with adolescents with ADHD.

21.10.4 Summary

Current gold-standard treatments for ADHD often do not produce sustainable effects (Hinshaw & Arnold, 2015; Molina et al., 2008) and fail to adequately address common impairments experienced by youth with ADHD (Fernandes et al., 2017; Hoza et al., 2005). This section briefly reviewed examples of new interventions (MFC, Supporting Caregivers, RELAX) targeting social and emotional impairments for youth with ADHD. Future research is needed to evaluate these treatments within larger and more diverse samples. Furthermore, additional research is needed to evaluate outcomes from alternative treatments compared to current gold-standard approaches. However, interventions such as MFC, Supporting Caregivers, and RELAX are promising examples of alternative treatment approaches to target emotion dysregulation and interpersonal conflict.

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22 Physical Exercise to Treat ADHD

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22.1 Introduction

According to the National Institute of Mental Health (NIMH) (2016), symptoms of ADHD are commonly treated with medications that elevate levels of thinking and attention-stimulating catecholamines (e.g., dopamine and epinephrine). However, pharma-logical treatments are typically not a stand-alone remedy for ADHD symptoms and are often paired with psychosocial training (Danielson et al., 2018). Additionally, of significant interest within the current chapter, physical activity (PA) participation may be an additional non-pharmaceutical strategy available for individuals with ADHD to manage their symptoms (Healthline, 2019).

Many distinctions must be considered regarding the effectiveness of PA as a non-pharmaceutical treatment for ADHD symptoms. First, several different modalities of PA exist, which differ in intensity, duration, and cognitive requirements. For example, the body's cardiovascular and metabolic responses are different when participating in long-distance running and high-intensity interval training (HIIT), and the duration of each session might also differentiate the effect on ADHD symptoms. Further, the cognitive demand for long-distance running is likely less than PA modalities that require coordination or teamwork such as sports, yoga, and martial arts. Another distinction central to this topic is the opportunity for acute (short-term) and chronic (long-term) symptom improvements. Ideally, both acute and chronic improvements would be achieved as a result of PA participation.

Overall, children with and without ADHD can improve attention as a result of various PA interventions (Cerrillo et al., 2015; Den Heijer et al., 2017). Studies of adults with and without ADHD reveal similar benefits (Buchman et al., 2007; Chapman et al., 2013; Colcombe et al., 2004). Additionally, no studies have been found that point to negative cognitive or behavioral outcomes as a result of PA interventions (Ng et al., 2017). Thus, PA participation appears to be an effective and low-cost strategy to improve ADHD symptoms in addition to or in lieu of pharmacological treatments. In this chapter, the improvements in ADHD symptoms associated with PA participation will be further explored. Various PA modalities will be discussed with regard to their research-supported effect on ADHD symptoms. With this knowledge, children and adults with ADHD can strategically implement PA into their life in order to maximize cognitive performance.

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22.2 Aerobic Exercise and ADHD

Aerobic physical activity (APA) consists of any exercise that improves cardiovascular conditioning, often referred to or understood as "cardio." The objective of performing APA is to increase the breathing and heart rate over a sustained amount of time, commonly achieved through low to moderate bouts of walking, swimming, cycling, and running. Aerobic means "with oxygen," as the oxidative energy system is utilized to provide ATP (an energy source for metabolic work) during APA (source). Aerobic exercise is different from anaerobic exercise (meaning without oxygen), consisting of short-duration, high-intensity movements, such as weightlifting or sprinting.

22.2.1 Aerobic Exercise and the Brain

The physical and cardiovascular health benefits of regular APA are well documented (Yang, 2019). Additionally, research indicates a connection between APA and improved cognitive abilities such as memory, attention, task-related brain activity, and executive function (EF) in adults and older adults (Buchman et al., 2007; Chapman et al., 2013; Colcombe et al., 2004). Adults with higher fitness levels tend to outperform unfit adults in cognitive tasks, as exercise improves brain plasticity (Klil-Drori & Hechtman, 2020). Positive associations have also been found between APA and academic achievement, cognition, psychosocial functioning outcomes, and behavior in children and adolescents (Lees & Hopkins, 2013).

22.2.2 Aerobic Exercise and Individuals with ADHD

Given the evidence of the cognitive benefits attributed to APA for normal functioning adults, adolescents, and children, it is reasonable to believe a similar opportunity to improve cognition exists for children with ADHD. Authors of recently published systematic reviews on ADHD and APA suggest short- and long-term ADHD symptoms exhibited by children, such as impulsivity, inattention, and hyperactivity, are reduced after partaking in aerobic exercise interventions (Cerrillo et al., 2015; Christiansen et al., 2019; Den Heijer et al., 2017; Tan et al., 2016). Adults with ADHD can also improve symptoms through APA participation (Gapin et al., 2015). A critical distinction within this chapter is the presence of acute (short-term) and chronic (long-term) APA intervention studies. Meta-analysis authors have determined that both acute and chronic interventions of APA have been shown to be helpful for children and adults with ADHD (Klil-Drori & Hechtman, 2020).

22.2.3 Aerobic Exercise and Brain Activity Studies

At a micro level, individuals with ADHD have difficulties regulating behavior, executive function, and impulses during complex tasks due to irregular cortical pathways (Sharma et al., 2015). APA participation produces similar effects as pharma logical treatments of ADHD, increasing catecholamines such as dopamine and norepinephrine in the brain, resulting in improved mood and cognitive functioning (LaCount et al., 2022). This cortical under-arousal is often detected within electroencephalographic (EEG) measurements, characterized by elevated theta activity and reduced beta within the brain of individuals with ADHD (Huang et al., 2018; Lubar, 1991).

22.2.3.1 Acute Effects

In a study by Huang et al. (2018), a sample of children with ADHD ($n = 24$ boys, Age = 7–12-years) and age-matched controls ($n = 28$ boys) underwent EEG measurements following interventions of video-watching (30 min) and treadmill exercise (5-min warm-up, 20 min at target heart rate, 5-min cool-down). The researchers observed no change for the control group after either intervention and significant decreases in theta/beta ratios after exercise interventions for the ADHD group (Huang et al., 2018). Thus, a single bout of APA may be sufficient for children with ADHD to normalize cortical arousal.

As increased theta/beta ratios are characteristic in the brain of an individual with ADHD, the same is true for lower P300 amplitudes. P300 amplitudes can be understood as a measure of neural event-related potential, where lower values signify unnecessary neuronal activity that may slow executive control and attention (Ludyga et al., 2017). Research suggests that aerobic exercise conditions (20-min on a cycle ergometer) increased P300 amplitudes more than coordinative PA (balancing task) for children with ADHD and age-matched controls (Age = 11–16 years) (Ludyga et al., 2017). Similarly, Chuang et al. (2015) reported normalization of neural arousal for children with ADHD (n = 19, no controls, Age = 8–12 years) following APA (30-min of treadmill walking), as well as improvements in cognitive tests. Therefore, acute bouts of APA can lead to normalization of neural arousal and improved cognitive performance for children with ADHD.

22.2.3.2 Chronic Effects

Chronic (long-term) interventions of APA are also beneficial for improving the neural conditions of children with ADHD. Given the results of a functional Magnetic Resonance Imaging (fMRI) study, where cognitive conditions improved for children with ADHD after 6 weeks of APA intervention (3 sessions per week, 90 min per session) (Choi et al., 2015). It is important to note that the activities in these studies were more challenging than in the aforementioned studies. They included multi-directional running, jump roping, and basketball shooting games performed within an aerobic level heart rate range.

Neurotransmission of catecholamines is essential to brain function, which research suggests is greater facilitated by acute exercise, and morphological changes to the brain are more influenced by chronic APA (Thomas et al., 2012). In a survey study of individuals (n = 1615 adults) diagnosed with ADHD as a child, greater participation in exercise was associated with individuals whose ADHD symptoms did not persist into adulthood (Berger et al., 2014).

22.2.4 Aerobic Exercise and Cognitive Performance Measures

For individuals with ADHD, difficulties in motor or cognitive abilities are common due to the aforementioned irregularities in cortical conditions they experience. Therefore, researchers have attempted to determine the relationship between APA interventions and performance measures of motor and cognitive ability for individuals with ADHD. Like brain activity studies, it is essential to delineate the performance benefits attributed to acute and chronic APA interventions.

22.2.4.1 Acute Effects

Since APA leads to improved neural and cortical performance for individuals with ADHD, it likely will lead to improvements in cognitive performance. A variety of APA modalities exist that might increase cognitive performance. Recent research has revealed a few APA modalities that can be utilized by individuals with ADHD in pursuit of increased cognitive performance. Researchers reported children (K-12) with ADHD who had performed 30-min of aerobic exercise (Cycle-Ergometer) demonstrated better results on tests of cognitive processing as opposed to after watching a nature documentary (Piepmeier et al., 2015). Additionally, research shows that cognitive test results have significantly improved for adults following 30-min bouts of stationary cycling (Mehren et al., 2019). Significant improvements in feelings of motivation and energy, with reduced confusion, fatigue, and depression, were observed in a population of young men (age: 18–33 years) with ADHD following a 20-min moderate-intensity stationary cycle ride (Fritz & O'Connor, 2016). Similarly, a sample of adults with ADHD (n = 14, mean age: 24.8) achieved fewer omission errors. It demonstrated faster reaction times during a cognitive task while walking on a treadmill (5 km per hour) compared to baseline (seated) (Rassovsky & Alfassi, 2018). Thus, short bouts of APA can lend acute (short-term) improvements for children and adults with ADHD.

22.2.4.2 Chronic Effects

Similar to brain activity research, evidence points to positive improvements in cognitive tasks for children with ADHD after chronic APA interventions. In a study of children with ADHD (trained: $n = 10$, mean age $= 12.2 \pm 2$ years; untrained: $n = 10$, mean age $= 12 \pm 1$ years), cognition (flexibility and selective) mental health (stress and depression) improved in the trained group of children with ADHD after participation in an 8-week swim training program (Silva et al., 2019). Additionally, Mohammadi Orangi et al. (2021) reported favorable outcomes for children with ADHD ($n = 36$, age $= 10$–13 years) who participated in a 6-week APA program combined with music. The trained group showed increased motor proficiency, perceptual reasoning, working memory, processing speed, and reduced anxiety and depression.

22.2.5 Aerobic Exercise Intensity and Time

It is important to determine whether low-to-moderate or moderate-to-vigorous intensities of APA have a different effect. Results of a systematic review by Khodaverdi et al. (2022) indicate that both chronic and acute interventions performed at both moderate-to-vigorous and at-least moderate-intensity serve to improve ADHD symptoms in participants. However, greater-intensity APAs negatively influenced attention during acute treatments. The cognitive improvements attributed to low-, moderate-, and vigorous intensity are well explained in an EEG study by Tsai et al. (2021). The authors reported vigorous-intensity APA is less effective than low- or moderate-intensity APA in terms of inhibitory control measured via cortical arousal within EEG scans of children with ADHD ($n = 25$, average age $= 10.54$ years). Finally, in regard to acute bouts of APA, more prolonged bouts of exercise seem to have a more significant effect (Vysniauske et al., 2016).

22.2.6 Age and Aerobic Exercise

As for age, the effect of APA is controversial, with some studies showing post-exercise benefits being greater for younger children (Fedewa & Ahn, 2011) and others reporting benefits to a general population of individuals up to the age of 25 years old (Verburgh et al., 2013). In a meta-analysis by Christiansen et al. (2019), it is confirmed that regular participation in APA during childhood and adolescence tends to reduce symptoms in early adulthood. Recall the evidence of improved cognitive performance attributed to APA for children, adolescents, and adults without ADHD (Chapman et al., 2013; Lees & Hopkins, 2013). Thus, the likelihood of benefitting ADHD symptoms through APA is greater than the risk of making them worse for individuals with ADHD of all ages.

22.2.7 Physical Fitness Levels and ADHD Symptoms

While bouts of APA have acute benefits for individuals with both low- and high-fitness levels, the benefits may be more attainable for those who partake in APA more regularly or who have a greater level of physical fitness. This notion was supported in a study of children with ADHD ($n = 16$, Average Age $= 11.38$ years), where children with high-fitness levels showed greater cognitive test improvements than children with low-fitness levels following acute bouts of APA (Skinner, 2021). Also, parent and teacher ratings of behavior for children (7–11 years) without ADHD show that overweight and obese children have significantly more behavior problems (Slykerman et al., 2020).

22.2.8 Sports as APA

Much of the interventions described in this chapter have included simple APA's such as walking, cycling, or swimming. However, more complex APA's, such as sports, have been studied to assess their effect on ADHD symptoms. Cognitive performance task improvements have been observed when children with ADHD participated in interventions, including various activities throughout multiple weeks. These activities consisted of table tennis (Memarmoghaddam et al., 2016; Pan et al., 2016; Pan et al., 2019) as well as football and basketball mini-games (Memarmoghaddam et al., 2016). An intervention that included a variety of sporting activities (racquet sports, volleyball, handball, balancing activities, climbing, wrestling, and track and field events) was found to be effective in improving executive functioning in children with ADHD ($n = 43$, age $= 7$–12 years) (Ziereis & Jansen, 2015). Additionally, in a study of 17 children (grades K-3) with symptoms of hyperactivity/impulsivity, the severity of ADHD symptoms decreased after an 8-week APA intervention (Smith et al., 2013). The intervention included 26-min sessions designed to increase activity through participation in games and activities that promote various motor skills, like activities seen in an elementary physical education classroom.

Thus, activities designed for sport or requiring more motor skills than alternatives of walking, cycling, or swimming can benefit symptom reduction. However, various sport disciplines exist to choose from, some of which require more cooperative skills in a team environment. Children with ADHD might have more difficulty controlling reactive aggression and following rules in a team sports environment than their traditional developmental peers. Those challenges may inhibit the cognitive benefits associated with their participation (Gapin & Etnier, 2014).

22.3 Anaerobic Exercise and ADHD

Anaerobic exercise (AE) encompasses the metabolic pathways where oxygen is not required to produce energy. In other words, the development and eventual breakdown of adenosine triphosphate (ATP), the molecule providing energy, occurs without the need for oxygen. The intensity of the exercise bout directly affects the amount of energy required for the activity and, in turn, affects the metabolic pathway for the development of ATP. Suppose the intensity of training outweighs the ability of the cardiovascular system to maintain levels of oxygen sufficient for sustaining aerobic metabolism. In that case, the result is that anaerobic metabolic pathways become the predominant means for ATP production. This, however, is short-lived, as anaerobic metabolic pathways cannot maintain production continuously and eventually fatigue due to depletion of metabolic substrates and increased acidosis. Examples of anaerobic activities include resistance training/weight lifting, interval training or circuit training, sprinting exercises while maintaining a high heart rate, high-intensity interval training, or other forms of strength training where fatigue is experienced within a relatively short amount of time.

22.3.1 The Relationship Between Anaerobic Exercise and ADHD

There is a paucity of research on individuals with ADHD examining the effects of *specific* anaerobic training regimes, the intensity of the load or speed at which training is conducted, and when to implement an overload or undulation principal. The overload or undulation principal refers to a moment during a training cycle to which the individual is recommended to alter training variables to avoid an excessive plateau of physiological adaptations. Overall research on physical activity in various forms, which have included some training bouts of anaerobic energy pathways, indicated statistical significance in improving executive functions and motor learning for both children and adults with ADHD (Suarez-Manzano et al., 2018; Piepmeier et al., 2015). Furthermore, previous literature has indicated mixed yet promising results for long-term improvements of executive functions in individuals with ADHD as a result of chronic physical activity adaptations (Suarez-Manzano et al., 2018). Executive functions such as emotional control, working memory, self-monitoring, and planning and prioritizing have an impact on cognitive function during active daily living (ADL) tasks. The general consensus among the scientific community is the improvement of executive functions by individuals with ADHD occurs post-participation in some form of physical activity. This may be due in part to the body's response to physical activity, specifically when the activity requires an increase in heart rate, blood pressure, and the reaction to micro-muscle tissue damage, otherwise known as *ultra-structural muscle damage* (Kraemer & Ratamess, 2005). An important question to determine is what types of physical activity elicit the greatest improvements in executive functions and health for individuals with ADHD.

Previous literature and research examining the response to physical activity in individuals without ADHD has indicated an increased release of neurotransmitters and hormones such as dopamine, norepinephrine, endorphins, and enkephalins (Kraemer & Ratamess, 2005). Furthermore, the reaction to anaerobic training, such as resistant training, requires immune responses of repair and regeneration of muscular-tendon tissue and an increase of anabolic and catecholamine pathways (Kraemer & Ratamess, 2005). As previously mentioned with APA, aerobic exercise activities similarly activate cortical arousal due to the catecholamine response to exercise.

22.3.1.1 Acute Effects of Anaerobic Exercise

Acute effects or adaptations of anaerobic exercise refer to changes subsequent to an initial exercise bout of moderate to high intensity. The perceived acute effects of anaerobic exercise with respect to individuals with ADHD have been measured through cognitive tasks and assessments to determine executive function capabilities. The measurable outcomes of acute effects identified in current literature include, however, are not limited to hormonal and neurotransmitter responses and metabolic, physiological adaptations (Piepmeier et al., 2015; Welsch et al., 2021). The current literature on acute perceived effects of anaerobic exercise on individuals with ADHD is mixed. Although a higher number of studies seem to indicate some level of short-term improvement in cognitive and executive function post-vigorous exercise bout lasting longer than 20-min (Mehren et al., 2020; Piepmeier et al., 2015; Suarez-Manzano et al., 2018). Piepmeier et al. (2015) cited multiple study findings that indicated child participation in a 30-min high-intensity exercise experienced improved vigilance and reaction measures as assessed with Conners' Continuous performance Test-11. However, the same meta-analysis review of current literature indicated negative cognitive performance responses following a 10-min intermittent high-intensity exercise bout (Piepmeier et al., 2015). Thus, the duration and intensity of the exercise bout may play a critical role in positive acute effects experienced post-exercise for individuals with ADHD.

The results for measurable outcomes of acute anaerobic activity not surprisingly follow a similar pattern to that of perceived effects. A longer duration of a vigorous exercise bout results in increased neurotransmitter and hormonal levels. Testosterone and growth hormone (GH) are both anabolic hormones associated with increased protein synthesis. Both play a role in tissue repair, and testosterone may affect brain formation during pregnancy which can lead to further potential risk for ADHD development. However, the latter is less understood and requires further research to fully grasp the relationship between levels of testosterone and brain formation during pregnancy. With respect to acute high-intensity exercise with a duration of 20 mins or more, both GH and testosterone levels increase for a short-term duration (Kraemer & Ratamess, 2005). However, minimal evidence or research exists as to the potential effects the increase of these two hormones may have on ADHD. Interestingly enough, testosterone and GH levels inhibit the release of cortisol hormones. Cortisol is a catabolic hormone associated with tissue remodeling and the breakdown of protein structures (Kraemer & Ratamess, 2005). Furthermore, excessive cortisol release is associated with increased stress, anxiety, and depression (Kholif et al., 2021).

Significant levels of cortisol have been reported in studies after an acute anaerobic exercise bout (Kraemer & Ratamess, 2005). Thus, there seems to be a complex feedback loop system in place to allow for adequate levels of cortisol while subsequently releasing testosterone and GH to inhibit the release of cortisol. Excessive cortisol release may negatively affect individuals with ADHD (Kholif et al., 2021). Therefore, inhibition of excessive cortisol levels is an important factor in understanding the acute effects of anaerobic exercise for individuals with ADHD. An important side note to consider, several studies have indicated increased salivary cortisol levels of ADHD in children who were prescribed methylphenidate treatment (Kholif et al., 2021). Thus, the potential for an increase of testosterone to an optimal level to inhibit the secretion of cortisol post-acute exercise bout may be beneficial for individuals with ADHD who are prescribed methylphenidate treatment. Nevertheless, research is recommended to validate such a claim.

As previously mentioned, key executive function deficits associated with ADHD are working memory, emotional stability, impulse control, and planning and prioritizing. Hormones and neurotransmitter groups associated with the executive functions mentioned above are the dopaminergic, noradrenergic, and endogenous opioid functions and systems (Brown, 2013). Catecholamine neurotransmitters and hormones such as epinephrine, norepinephrine, and dopamine are associated with executive function ADLs and have short-term increase post-acute exercise bouts (Suarez-Manzano et al., 2018). Furthermore, systemic release of endogenous opioid pathways has been indicated with acute vigorous exercise bouts lasting longer than 30 mins (Kraemer & Ratamess, 2005). Thus, enhancement of mood, increased planning and task orientation, and decreased impulsivity may be positively affected by vigorous or moderate- to high-intensity exercise.

Lastly, estrogens secreted primarily by the ovaries play a role in executive functions such as emotion control and flexible thinking. Current literature is limited regarding the specific anaerobic training regimes and their effect on estrogen secretion. Nevertheless, the few primary studies that exist do indicate a potential increase of estrogen secretion with an acute exercise bout of vigorous activity (Kraemer & Ratamess, 2005). The limited research does pose some promising findings regarding vigorous exercise and estrogen secretion; however, further evidence regarding menstrual timing and anaerobic exercise correlated with higher secretion levels of estrogen and potential benefits to individuals with ADHD is warranted.

22.3.1.2 Chronic Effects of Anaerobic Exercise

The available literature and research conducted on the chronic effects of long-term anaerobic exercise is limited. There are minimal ADHD studies that attempt to analyze the chronic effects of specific anaerobic training regimes over a long-term intervention period. There are, however, long-term anaerobic studies on individuals without ADHD and the hormonal, neurotransmitter, and overall adaptive response that occurs over a period of time. Furthermore, the current studies in the literature addressing the chronic effects of physical activity do include bouts of high-intensity exercise in the training regime. Nevertheless, there is not a clear consensus as to what specific variables of anaerobic exercise routines should be implemented to optimally improve symptoms of ADHD.

For individuals without ADHD, long-term anaerobic training results in increased hormonal and neurotransmitter responses, such as endorphins, enkephalins, testosterone, GH, and catecholamines (Kraemer & Ratamess, 2005). However, the increased hormonal responses have shown to diminish quickly after an exercise bout and even diminish over a long-term period of time, so that blood serum levels return back to pre-workout states relatively quickly. Only when an overload or undulation principle is implemented are longer duration of systemic hormone levels increased (King, 2016). In other words, avoiding a fitness plateau and altering the workout routines may elicit greater improvements in hormonal secretion on a systemic level. Several studies have demonstrated long-term high, vigorous-intensity activity may improve executive functions in children with ADHD (Chuang et al., 2015; Piepmeier et al., 2015). Furthermore, the literature does indicate long-term anaerobic training as a viable addition to other treatment modalities such as medication (Medina et al., 2010). For instance, Katz et al. (2010) examined the relationship between high-intensity physical activity and medication intake. The researchers found the long-term bouts of high-intensity exercises resulted in a decreased amount of stimulant medication taken by the children with ADHD.

22.3.2 Practical Application

Developing a successful anaerobic exercise program for individuals with ADHD as a prescription to either take the place of medication or add to the effectiveness of medication is a complex task. Understanding the current literature and landscape of data regarding the acute and chronic effects of anaerobic training is paramount in the practical application of said knowledge.

Current literature, although minimal with respect to specific anaerobic training regimes, seems to indicate both chronic and acute training applications improve ADHD symptoms and potentially can reduce the usage of pharmaceuticals. Stimulants and other pharmaceuticals such as methylphenidate, which is a catecholamine stimulant and is used to treat ADHD, may be decreased in dosage with adequate anaerobic training regimes (Medina et al., 2010). Prescribed anaerobic training may be a viable medication replacement; however, the literature seems that most individuals with ADHD may need to remain on a lower dosage of pharmaceuticals (Welsch et al., 2021). This is due in part to the hormonal and neurotransmitter response to both acute and anaerobic exercise. Vigorous exercise bouts of more than 30 min or more have similar effects to pharmaceuticals such as methylphenidate (Medina et al., 2010; Welsch et al., 2021). Several studies noted the importance of undulating training regimes to avoid a plateau of hormonal and neurotransmitter increase or release (Grassmann et al., 2016; Piepmeier et al., 2015). Researchers observed chronic adaptations have the potential to decrease or plateau over time, resulting in lower hormonal and neurotransmitter secretion. Training regimes of more than 12–16 weeks at a time tended to result in the adaptation plateau response (Suarez-Manzano et al., 2018). When prescribing prolonged anaerobic training bouts, it seems warranted to employ the overload principal prior to the onset of plateau of the chronic adaptive response that may be experienced by individuals with ADHD. These claims need further validation and research as to the exact training variable manipulated, the timing to implement an overload or undulation of the training cycle, and specific exercises over a long-term intervention to determine optimal symptom reduction. Nevertheless, the potential to reduce pharmaceuticals over time with the increase of anaerobic physical activity is promising and worth researching.

In addition to an undulating cycle of intensity, previous research has demonstrated the need for various types of anaerobic training techniques that may target specific symptoms experienced by an individual with ADHD (King, 2016). Furthermore, including anaerobic training principles that are cognitive-training-based and game-based tasks may be beneficial for an individual with ADHD. For instance, children may benefit from anaerobic training and high-intensity physical activity that incorporates body awareness, movement, and complex footwork skills (King, 2016). In addition, cognitive skills such as memory recall during anaerobic training have been shown to elicit potential upregulation of growth factors in the brain (Mehren et al., 2020). For instance, Lista and Sorrentino (2010) observed positive changes in brain-derived neurotrophic factor (BDNF) following physical activity. BDNF is a growth factor involved in brain development within the regions of the hippocampus and neuroplasticity of learning and memory processes (Erickson et al., 2011); Lista & Sorrentino, 2010).

When developing an anaerobic training program, it is important to take into account several factors in order to promote a potential decrease in symptoms of ADHD. Understanding the full nature of the individual's ADHD symptoms and potential impairments of executive functions should be taken into account. Implementing various anaerobic exercise strategies to elicit a physiological response via neurotransmitter and hormonal release is warranted. Nevertheless, targeting the symptomology of the individual's ADHD may assist in improving executive functions. For instance, introducing game-based tasks may reinforce capacities for improved behavior and emotional control. Furthermore, including cognitive decision-making tasks to encourage goal attainment may assist in concentration improvements (King, 2016). Thus, an approach to the program should include both training for physiological catecholamine response and addressing the individual's ADHD symptomology identified. Refer to Table 22.1 for a list of potential applications of anaerobic training principles.

22.4 Martial Arts and ADHD

Martial arts training provides an excellent opportunity for people to develop themselves beyond that of developing martial prowess or fighting skills. Other benefits of training in martial arts include increased mental well-being (Croom, 2014) and mindfulness (Lothes et al., 2015). Different martial arts also offer different types of training. Some martial arts offer more explosive aerobic and anaerobic style training, such as Brazilian Jiujutsu (Lorenco-Lima et al., 2020). While other martial arts, such as Tai Chi (Webster et al., 2016), may focus less on physical exertion and offer other benefits such as increased mental health, focus, and other benefits. Other martial arts may sit between these, such as Aikido, offering its practitioners aerobic and anaerobic activity and assisting in the development of cognitive skills such as mindfulness (Lothes et al., 2015).

Table 22.1 ADHD and potential application of anaerobic exercise programs

Executive function or other impairments	Potential need	Exercise recommendations	Undulation
Working memory	Requires structure	Structured workouts, routine during the week. Often led by an instructor. Group fitness beneficial	Overload intensity 6–8 weeks to promote memory retention
Emotional control	Measurable outcomes	Set measurable training goals, ex. Attain a specific time for a sprint and squat a specific number of repetitions or weights	Shift intensity dependent on achieving goals
Planning and processing	Consistency of structure	Define goals, and set structured workouts planned within a routine. Recommend joint effort in designing routine	Shift intensity dependent on achieving goals
Impulse control	Variety of new skills	Implement a variety of workouts within a structured exercise regime, including multiple functional training types	Undulate often, mixing up training loads—interval or circuit style
Task initiation	Ownership/ buy-in	Set structured workout through joint effort design. Provide ownership and flexibility in the types of exercises	Allow for flexible undulation of training loads
Flexible thinking/ shifting	Variety/new skills	Incorporate various functional movements during each training bout. Flexible program design	Increase training loads often, implement new movements during a training session
Motor skills	Progression of complexity	Incorporate complex footwork and skills and progress slowly early on in structure program design to more difficult techniques	Utilize cognitive training during exercise bouts. Implement memory recall activities in-between sets of exercises

Waldera and Deutsch's (2021) article in *The Physical Educator* discusses the potential benefits of both aerobic and anaerobic physical activity on ADHD symptoms. Their article discussed the mixed results of outcomes when parents and teachers are reporting on children's ADHD symptoms after they have engaged in some form of physical activity—suggesting that parents look to find the right fit of physical activity for their particular child and that there is no one-size-fits-all model for physical activity and individuals with ADHD.

Another comment of note that came out of Waldera and Deutsch's (2021) article was that how team sports or sports with many rules may lead to challenges for individuals with ADHD and that these individuals may also have trouble adhering to all the rules and controlling reactive aggression during these sports. This is where martial arts training may become an optional physical activity for individuals with ADHD. Most martial arts training does not have a lot of "rules" that individuals need to be aware of during that activity, like you might find in soccer or football. Additionally, martial arts training has been shown to actually help train an individual to control or reduce their reactive aggression, especially in children and adolescents (Lafuente et al., 2021).

22.4.1 Mindful Movement Martial Arts and ADHD

Mindfulness-based interventions have been used in conjunction with medication and behavioral treatments for ADHD and have shown promise for managing ADHD symptoms (Evans et al., 2018). Mindfulness training has also been shown to help with improvements in attentional control (Lutz et al., 2009), which is a problem faced by many individuals with ADHD. Individuals with ADHD have trouble dealing with attentional control and self-regulation (Grane et al., 2014). Mindfulness training has been shown to help improve these cognitive processes (Tang et al., 2007).

Mindfulness training may be a helpful supplement in addressing ADHD symptoms in individuals. Recent research shows promise that a Mindfulness-Based Treatment can improve some of the core symptoms of ADHD, such as dealing with attention and executive control (Cairncross & Miller, 2020). Mindfulness-based interventions can help cultivate attention processes that lead to better awareness, being more present at the moment, attention regulation, and emotion regulation (Evans et al., 2018).

Clark et al. (2015) have postulated that mindful movement practices can improve executive and attentional control by providing opportunities for individuals with ADHD to learn functional coordination and attention. They also contend that individuals will refine how to engage in behavioral inhibitory responses through mindful movement practices. Clark et al. (2015) propose that mindful movement practices can help as a variant of the Focused Attention (FA) that many sitting mindfulness practices encourage. They have referred to this process as "contemplative movement" (Russell & Arcuri, 2015).

Movement acts as a concrete observable sensation that can provide consistent feedback to individuals to facilitate their discovery and refinement of techniques. This can help play a role in both attentional control to the behavioral skill and self-regulation. Clark et al. (2015) have suggested that effort or sustained attention maybe not be as necessary for the training of attentional skills through a mindful movement practice, but rather it becomes a byproduct of it, therefore cultivating a "mindfulness presence" in individuals. When individuals focus on movement with intention and the consequences of those movements, then the association between behavioral control, either expression or inhibition, becomes stronger (Clark et al., 2015). Therefore, mindful movement is capable of training control skills in an individual so that they can coordinate goal setting, attentional control, and motor control, especially in cases where the individual may have trouble inhibiting impulse reactions due to dysregulation like in cases of ADHD.

22.4.2 Aikido and Mindful Movement in Relation to ADHD

Aikido is often referred to as a meditation in motion by its practitioners because of the heightened awareness and attention to technique that is ascribed to training (Dobson & Miller, 1978; Saotome, 1986, 1989). Much of Aikido's history is influenced by Buddhism, which includes some form of mindfulness practice (Shimizu, 1994; Stevens, 1993). Meditation (mindfulness) practices and breathing exercises have been part of Aikido training since the inception of the martial arts early days (Stevens, 1993). The practice of Aikido usually involves starting the class with some form of basic body movements, referred to as Aiki Taiso. These Aiki Taiso allow for practitioners to practice deliberate movements without a partner and pay attention to what is going on within them and around them. These practices help the Aikido practitioner learn to cultivate awareness of their body through movement and breathing. Another practice that is often done in Aikido classes is called Tai Sabaki, which is a partner practice in learning to cultivate awareness of self in space and connection with someone else. Then the practice is moved on to using these basic movements of Aiki Taiso and Tai Sabaki to start moving and throwing their partners and engaging in the basics of technique (Kihon Waza). These foundational movements of Aiki Taiso, Tai Sabaki, and Kihon Waza all help Aikido practitioners learn how to control and regulate themselves during this practice so that they do not injure their training partners. The Aikido practitioners have to be aware not only of themselves but how their actions will affect their partner (Westbrook & Ratti, 1970; Shifflett, 1999). As Clark et al. (2015) have pointed out, mindful movement practices can help to facilitate the same focused attention that is achieved through sitting meditation practices.

Lothes et al. (2015) conducted a longitudinal study on a small ($N = 5$) number of participants that started Aikido with a university club and continued to get their black belts. They found that as people practiced Aikido, their mindfulness scores gradually increased from when they started training Aikido until they achieved their black belts. To be able to collect this data from the start to the black belt, the longitudinal study took over 5 years.

Lothes et al. (2013) surveyed 86 novice Aikido practitioners (individuals that had not achieved a black belt) and 53 experienced (those that had achieved a black belt in Aikido) Aikido practitioners, and 20 control participants with no martial arts training. They used the Kentucky Inventory of Mindfulness (KIMS; Baer et al., 2004) and the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003) in their study. They found that self-reported levels of mindfulness differed between novice and experienced Aikido practitioners, with experienced Aikido practitioners reporting significantly higher levels of mindfulness on both scales than novice Aikido practitioners. They also found that both of these groups of Aikido practitioners had significantly higher mindfulness scores than a control group of non-martial arts practitioners.

According to Clark et al. (2015), if the mindful movement can improve executive and attentional control by providing opportunities for individuals with ADHD to learn functional coordination and attention, then it is plausible that Aikido can be a martial arts medium that people with ADHD can benefit from. Aikido's increases in mindfulness scores and contemplative movements could also be a potential benefit for increased Focused Attention (FA) through training. Aikido may be an alternative option for individuals with ADHD when sitting meditation may be too difficult for them.

22.4.3 Qigong and ADHD

In a pilot study conducted by Rodrigues et al. (2019) using TaijiQuan and Qigong exercises with a small sample ($N = 4$) of students that were showing symptoms of ADHD, oppositional defiant disorder (ODD), and conduct disorder (CD), they found improvements across participants. Participants aged between 6 and

10 years old and had been referred to a clinical psychologist for “difficult” behaviors in the classroom. All participants did receive an ADHD diagnosis from the clinical psychologist.

They administered a total of 30 sessions lasting 20 min once a week. TaijiQuan Yang Style 8-movement form and Qigong Ba Duan Jin were taught to the participants by a qualified TaijiQuan/Qigong instructor. TaijiQuan puts its focus on controlling breathing, focusing the mind, and a soft, fluid control of movements during practice. Qigong practice focuses on clearing the mind, slowing down, and controlling physical movements with a concentration on muscle relaxation and synching this with the practitioner’s breathing. Across all participants, they showed improvement in ADHD symptoms. Overall, the participants’ teacher reported observed improvements in the participants’ behaviors, performance in the classroom, and grades. During the interview process after the intervention, the participants reported feeling more relaxed and calm during and after the practices. The participants also recognized that TaijiQuan and Qigong movements helped them to gain control over themselves and also helped induce feelings of happiness and joy while doing the movements.

22.4.4 Tai Chi and ADHD

Tai Chi has grown in popularity among people wanting to engage in mind-body movements that encourage mindful attention to the body as it is moving. Tai Chi is a low-impact flowing movement exercise that has been shown to help with ADHD, mental focus, body awareness, and attentional shift (Wayne, 2013). Tai Chi benefits have also been shown to help individuals in both mental and physical health (Webster et al., 2016).

Hernandez-Reif et al. (2001) conducted a pilot study on 11 adolescent males (age 14.5 years) over a 5-week period. The participants were taught Tai Chi postures two times a week over the 5-week period. After the 5-week period was over, results showed that the children doing Tai Chi had less anxiety, improved classroom conduct, less daydreaming, less inappropriate emotions, and less hyperactivity. The study also found that these results persisted after a 2-week follow-up period where participants were not formally practicing Tai Chi.

Converse et al. (2014) conducted a study assessing students taking a Tai Chi class ($N = 28$) at a university against a control group ($N = 44$). They assessed ADHD indicators and cognitive functioning at 3 points over a 15-week period. Tai Chi students attended 2×50 m classes a week for 15 weeks. There were approximately 20 students per class. The first 3 weeks of the course were introductory and focused on gait, posture, and Tai Chi principles, followed by instruction on the 24-form Yang style sequence. The control group received no training.

Participants were administered a series of cognitive tasks and self-report measures at the beginning of the study. Then 15 weeks later, after the semester ended, students were assessed again on these same measures. The results showed a significant decrease in the Inattention scale scores for the Tai Chi group. The Tai Chi students also showed greater reductions in inattention when compared to the control group. The Tai Chi group’s self-report of attention, but not hyperactivity-impulsivity, improved over the duration of the study. They also found that improvements in attention were correlated with reductions in reaction variability across the Tai Chi group.

22.4.5 Taekwondo (TKD) and ADHD

In recent years TKD has received research attention on its potential benefits for adolescents and emerging adults (Cho et al., 2018; Petrovic, 2017). Taekwondo is a Korean martial art that engages students in cognitive, emotional, physical, social, and educational processes (Cook, 2006). Some preliminary research (Lakes & Hoyt, 2004) has shown promise in martial arts training in K-6 students over 3 months of training when compared to a regular physical education course.

Kadri et al. (2019) ran a year-and-a-half-long longitudinal study examining how Taekwondo (TKD) training may affect students with ADHD. They matched the TKD group against a control group and found that TKD training helped in symptom reduction of ADHD symptoms. Between September 2015 and February 2017, Kadri et al. (2019) conducted a randomized control study on 40 patients (36 male and four female) with ADHD in Tunisia. Participants were randomly selected into one of two groups, either a TKD intervention group or a control group. The average age for both groups was 14 years old. They used the Stroop and Ruff tests (Frazier et al., 2004) to assess ADHD symptoms.

The TDK group met 2 × week for 50 min each session for a year and a half. The participants attended sessions at a private martial arts school. The TKD intervention consisted of a technical skill development such as punching, kicking, and blocking. The participants also engaged in TKD forms, which are a series of choreographed movements working on the participant's technical precision done in a predetermined order. The forms process engaged students in attentional control to be able to pay attention to and execute the movements in the correct order and with precision. The students were expected to be able to perform the movements that had been previously learned as well as the new ones that were taught. Before and after each training session, the participants engaged in a 10 min warm-up and recovery. The TKD intervention was conducted by qualified TKD instructors.

The results of this study produced some promising results for TKD training to benefit individuals with ADHD. They found significantly better scores reported for both Stroop and Ruff tests in the TKD condition versus the control condition. This may indicate that TKD training can help benefit individuals with ADHD. The TKD group outperformed the control group on all the cognitive dependent variables: Stroop and Ruff tests. Both groups did not show statistical differences in these tests at the start of the study. Given the cognitive and social benefits that have been shown with TKD training, TKD may be another avenue of interest for individuals dealing with ADHD to supplement traditional treatment methods.

22.5 Yoga and ADHD

Pharmaceutical intervention may be effective in the management of ADHD; however, a growing body of evidence suggests that alternative or complementary treatments may optimize benefits and minimize side effects. The utilization of yoga practices in ADHD populations grows as the benefits become increasingly recognized. Yoga is a vast body of knowledge that combines breathing techniques, postures, and cognitive control, which can be effective in moderating symptoms associated with ADHD (Chou & Huang, 2017; Jensen & Kenny, 2004). The practice has been shown to positively affect physical and mental states in clinical and non-clinical settings (Chimiklis et al., 2018). The combination of breathwork, movement, and meditation can help promote improved self-control, attention, body awareness, and stress management and relieve symptoms such as hyperactivity, impulsiveness, and inattentiveness (Kumari, 2019).

The word yoga is rooted in Sanskrit origins and can be translated into to join, to yoke, to bind, and to direct and focus one's attention on. Yoga is considered a path to self-realization, bringing conscious control to the mind and its actions. Patanjali, recognized as the father of *Raja Yoga,* states that yoga aims to "calm the chaos of conflicting impulses and thoughts" (Garner, 2016).

Yoga has been shown to positively influence self-regulation, attention, academic performance, and executive function. Additionally, yoga can affect sympathetic nervous system regulation and hypothalamic–pituitary–adrenal system control, contributing to decreased anxiety and depressive symptoms (Chimiklis et al., 2018). These symptoms are often comorbidities of ADHD symptoms. Children with ADHD may also present with reduced dopamine levels, and the theoretical basis exists that yoga may increase dopamine release in the CNS (Mehta et al., 2011). Mind-body practices can also influence neurotransmitter levels, as evidenced by a mass resonance spectroscopy (MRS) study that showed increased thalamic GABA levels following yoga sessions (Sharma et al., 2015). There is evidence to support anatomic changes resulting from mind-body practices, such as thicker cortical regions in long-term meditators than in matched controls. These cortical regions are associated with attention, interoception, auditory and visual processing (Sharma et al., 2015).

Yogic breathing techniques, known as *pranayama,* are safe and effective practices that have been shown to influence neurocognitive abilities, autonomic and pulmonary functions, and biochemical and metabolic functions in the body (Saoji et al., 2019). The research is compelling for yoga as a treatment modality as yogic breathing may facilitate slower brain wave amplitudes and neurotransmitter activity, demonstrating its benefits in the use of ADHD treatment (Jensen & Kenny, 2004). Individuals with ADHD have been shown to have reduced vagal parasympathetic activity, and yogic breathing techniques have been shown to modulate autonomic nervous system activity, therefore, positively impacting emotional regulation (Sharma et al., 2015).

It has been hypothesized that ujjayi breath, a yogic breathing pattern in which one partially closes the glottis to increase airway resistance, may contribute to regulating the autonomic nervous system (ANS) through the stimulation of vagal afferents (Pearson et al., 2019). Additionally, diaphragmatic breath directly affects neuroendocrine regulation, cortisol regulation, psychoemotional epigenetics, GABA system, and HPA axis regulation (Garner, 2016). When breathing patterns slow to six breaths/minute or less, vagal afferents are stimulated to shift the autonomic nervous system to a parasympathetic dominant state. These vagal pathways, mediated by the thalamus, have the potential to improve emotional control and attention (Pearson et al., 2019).

While ADHD tends to be treated as a cognitive problem, motor features of the disorder are also represented in the core aspects of ADHD. Motor control impairments parallel cognitive and behavioral impairments, such as decreased inhibitory control of movement (Clark et al., 2015). The physical postures, known as *asana*, associated with yoga can improve fitness, flexibility, memory, concentration, and strength in those with ADHD (Beart & Lessing, 2013; Kumari, 2019). When the physical aspect of yoga is combined with the breath, the overall circulation in the body is improved, resulting in a release of tension, increased blood flow, and improved oxygen levels throughout the entire body, therefore affecting the central and autonomic nervous systems (Peck et al., 2005).

Mindful movement practices can potentially contribute to improved control of attention. Clark et al. (2015) note that movement generates concrete sensations that can act as feedback when training self-regulation and skill. The authors emphasize this point to contrast thought-based processes that may lack a readily observable phenomenon. They hypothesize that the practice of mindful movement may improve executive attention and control and allow one to maintain attention in the presence of distraction.

The combination of breathing techniques, physical postures, and long periods of concentration associated with yogic practices may reduce attention deficit, improve strength, concentration, and calm the senses (Kumari, 2019). The benefits of mindful interventions may include increased awareness, increased presence, and an improved sense of self (Evans et al., 2018). Mindful intervention also typically leads to improvement in a sense of calm, contentment, and overall emotional regulation strategy (Evans et al., 2018).

Meditation is considered a key component of a yoga practice; however, the literature is not clear on one definition of meditation. Sometimes it is viewed as an altered state of consciousness, while others describe it as a mental training technique (Chimiklis et al., 2018). Meditation techniques can be generalized into concentration meditation and mindfulness meditation. Concentration meditation involves stilling the mind by focusing sustained attention on an object. Mindfulness meditation focuses on developing an open awareness to the contents of the mind. Many meditation practices utilize a combination of concentration and mindfulness meditation (Krisanaprakornkit et al., 2010).

In their systematic review and meta-analysis, Chimiklis et al. (2018) sought to investigate how the combination of breathing practices, physical postures, and meditation influence ADHD-related outcomes in youth ages 5–17. Utilizing a meta-analysis in addition to the systematic review provides a more precise estimate of the effectiveness of the intervention and controls for studies with small sample sizes that are often represented in the current literature. The results agreed with the previous research findings that these interventions have a statistically significant effect on key processes such as executive function, behavioral self-regulation, and attention (Chimiklis et al., 2018).

In addition to examining the effect of yoga, meditation, and mindfulness interventions in youth diagnosed with ADHD, the authors also reviewed parent and teacher reports and examined the parent–child relationship. The authors posit that longer treatment sessions may result in greater improvements in ADHD symptoms, likely through increased comfort levels in children acquiring and utilizing skills, stronger neural mechanisms such as executive functioning, and improved physiological responses such as increased cortisol. An important finding was that participation by both parent and child, as opposed to child only, demonstrated improved ADHD symptoms in children and improved well-being for both child and parent (Chimiklis et al., 2018).

In 2018, Evans et al. published a systematic review and qualitative summary of yoga, mindfulness, and meditation studies of youth with ADHD. Mindful interventions that involved both parent and child demonstrated parent outcomes such as reduced stress, reduced overactivity, increased satisfaction, and increased happiness. Quantitative and qualitative data suggested warmer parent–child relationships following the combined parent–child mindful intervention. The improved parent–child relationship was then associated with less child externalizing behavior. Although there are differences in yoga and mindfulness practice protocol throughout the literature, the overarching theme may be directing attention toward present-moment experiences.

Mehta et al. (2011) showed significant results when integrating yoga and meditation for children with ADHD in a program taught by high school volunteers. The study consisted of a 6-week multimodal behavior program that included yoga and meditation. Social and performance impairment scores showed significant improvement pre and post-test and a significant improvement in behavior scores. The results were independent of age, gender, and ADHD type. Although this pilot study consisted of a small sample size ($n = 64$), the results suggest that additional research with a more rigorous methodological design may be warranted (Mehta et al., 2011).

Jensen and Kenny (2004) conducted a small RCT ($n = 19$) on boys ages 8–13 years old to examine the effect of yoga on attention and behavior after 20 sessions of yoga compared to a control group. The intervention included respiratory training, postural training, relaxation training, and concentration training. The authors reported a moderate reduction in oppositional behavior compared to the control group per parent and teacher reports. Additionally, the yoga group demonstrated significant improvements in emotional lability. While this is not generally considered a defining characteristic of ADHD, it has been shown to impact the manifestation of the disorder.

The impact of ADHD on adults should not be ignored. A diagnosis of ADHD is often overlooked in adults, contributing to social and occupational risk. Adults with ADHD have lower high school graduation rates and hold fewer 4-year degrees than the general population. They are more likely to miss work, contributing to annual losses in productivity. Additionally, research suggests that pharmaceutical intervention in adults may be less effective than in children (Lake & Sarris, 2019). Evans et al. (2018) cite an increased mortality rate in individuals with ADHD compared to controls. Considering the low cost and the minimal risk of adverse effects, the implementation of yoga practices should be considered in the adult management of ADHD symptoms.

Zhang et al. (2018) conducted a systematic review and meta-analysis evaluating six RCTs of meditation-based therapies in adults, with 8 weeks representing the average length of intervention. The authors concluded that meditation-based therapies were significantly more efficacious than the control conditions in adults when considering the core symptoms of ADHD. Regarding neurophysiological measures, the authors specified that inhibition and working memory demonstrated significant results; however, no significant effects were recorded when measuring inattention. A lack of significant results was also a concern, specifically regarding hyperactive/impulsive symptoms (Zhang et al., 2018).

Bueno et al. (2015) conducted an 8-week study of mindfulness-awareness practices in adults 18–45 years old diagnosed with ADHD compared to healthy controls. The authors hypothesized that mindfulness-awareness practices would improve attentional performance, improve mood, and result in a better quality of life. The study concluded that mindfulness-awareness practices improved the effect and attention of adults with ADHD as well as controls (Bueno et al., 2015).

Current research supports yoga as a modality to moderate the symptoms of ADHD; however, limitations are present in the literature. Future investigations should include a higher standard of methodology, such as randomized controlled trials with large sample sizes. The risk of bias is also a concern. Medication bias should be considered, as the consistency of medication has not been reported in much of the current research. Many studies have a high rate of attrition. Improvements are needed in recording post-intervention follow-up data to better evaluate long-term results. Additionally, further information about participants should include a range of severity of ADHD and subtypes to improve the generalizability of the results. Studies may be designed to include child-only, parent-only, and parent–child results with yoga intervention.

Intervention protocols are a missing piece in yoga and ADHD research. Current literature suggests that longer treatment interventions will result in better outcomes. Researchers posit that this may result from the opportunity that participants have to acquire the skills and use them consistently over the desired time frame, improving physiological responses and facilitation of neural mechanisms (Chimiklis et al., 2018).

Standardization of treatment would be helpful to validate the efficacy of interventions. Researchers should precisely report intervention length and type so the study design can be replicated. Future research may focus on determining the optimal frequency, intensity, and duration of treatment. Breathing, movement, and meditative yoga practices may be evaluated as a whole and as individual pieces on their own. Finally, further research should address whether yoga and meditation-based therapies could serve as a stand-alone treatment for ADHD or if they are better suited to complement other pharmacological and non-pharmacological interventions.

22.6 Conclusion

In conclusion, a variety of PA modalities have been shown to help individuals with ADHD to manage their symptoms. The benefits of PA for individuals with ADHD have been supported by the evidence of improved brain activity, cognitive performance, social performance, attention, as well as teacher-, parent-, and self-reports of symptoms. Additionally, the benefits of PA to ADHD symptoms can be both chronic and acute. An exercise program that integrates both the acute and chronic benefits attributed to PA might be optimal, where acute sessions are strategically scheduled in a timeframe where short-term benefits are optimal (e.g., before school, a test, or a meeting) but overlap with long-term improvements of symptoms (Wigal et al., 2013). Finally, it is important to note that very few, if any, APA interventions within the research have worsened ADHD symptoms in children or adults (Ng et al., 2017).

APA can be performed via several different modalities, some simple and inexpensive (walking, cycling, and swimming), some more complex and requiring equipment (sports, physical education activities, balancing skills, and climbing). Evidence suggests that APA performed at a vigorous level may not be as effective as moderate or moderate-to-vigorous intensities. In terms of exercise session length and frequency, it appears longer and more frequent sessions are recommended. APA is beneficial for both children and adult populations, and APA participation during youth can reduce symptoms into adulthood. Fitness levels and ADHD symptoms are related; that is, obese children with ADHD have worse behavior reports than their more-fit peers. Also, children with higher fitness levels tend to experience greater benefits to symptoms than their low-fitness peers.

Anaerobic training may occur in many different forms depending on the individual's training level and the intensity to which the exercise is conducted. For younger population groups, bodyweight, suspension training, weight lifting, or sprinting exercises can all be classified as anaerobic training. Oftentimes, physical activity that is deemed anaerobic is experienced or described as vigorous. From a practical application viewpoint, it is recommended to prescribe exercises at or near-maximal intensity in short bursts of activity. Rest times should increase as intensity increases to allow for a full recovery. This, in turn, will result in an anaerobic effect and acute adaptations. The acute adaptations, specifically an increase in the secretion of hormonal and neurotransmitter pathways, have been shown to positively affect ADHD symptoms. In other words, prescribing acute bouts of vigorous exercise may be beneficial for individuals with ADHD and could potentially reduce the use of pharmaceuticals to curb symptoms. Furthermore, the addition of complex footwork and increased velocity exercises may improve motor learning while promoting anaerobic system activation. For individuals with executive function impairments exhibiting memory recall and focus disruption, cognitive activities included in training programs may prove beneficial for long-term improvements in symptomatology. In summary, the health benefits from anaerobic training are evident for all individuals regardless of ADHD symptoms. As such, prescribing cycles of anaerobic training to individuals with ADHD may not only curb symptoms but overall improve their health and quality of life.

Martial arts training may act as a supplemental benefit to traditional treatments of ADHD. However, which martial art is best for which person comes down to personal preferences. Some people may prefer the slow movement-based style of Tai Chi over the striking and kicking style of Taekwondo. Others may find that the throwing and pinning aspects of Aikido are more their style than that of Tai Chi. Ultimately people will need to try the different martial arts out there and see which one is likely to benefit them the most. To date, these are the martial arts that are in the literature for benefits with ADHD. The research is not out on other martial art styles and if they benefit individuals with ADHD. Another thing to be mindful of with martial arts training and ADHD, just like with any cognitive or behavioral treatment for ADHD, it takes time. It is not likely that symptoms of ADHD will go down or away in only a couple of classes. Within most of these studies, there was a minimum of 5 weeks of participation before any outcomes were measured. It is recommended that if a martial arts regiment is going to help supplement traditional ADHD treatments, you need to give it some time.

Yoga is an ideal component of ADHD intervention as it is cost-effective, accessible, and has a low risk of adverse effects. The holistic combination of breathing, physical postures, and meditation supports a comprehensive approach to treatment that many studies have shown to effectively manage symptoms associated with ADHD. The physical, mental, and physiological effects of breathing, movement, and meditation may be examined independently. However, it is likely the cumulative impact of these practices that makes yoga so beneficial, influencing neurochemical, immune, and biochemical processes within the body.

While the literature shows that yoga *can* make a difference, specific guidelines and protocols necessary to create positive change remain unclear. In general, longer durations of practice yield better results. When treating youth with ADHD, yoga involving both children and parents may be more effective than children alone. Finally, the research does not examine whether yoga could be an independent intervention for children or adults diagnosed with ADHD or is better suited to enhance other interventions.

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23 Telemedicine to Manage ADHD

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Telemedicine or telehealth (hereafter referred to as telemedicine) is the delivery of health care across distances, including health care taking place by telephone and through web-based platforms such as videoconferencing (Craig & Paterson, 2005). Telemedicine has gained popularity for use in the field of mental health over the past 20 years and holds promise, particularly for reaching marginalized populations, as it reduces stigma and provides increased access to underserved populations, such as those in rural areas and individuals from lower socioeconomic statuses due to the removal of transportation and childcare barriers (e.g., Reese et al., 2012; Ryan et al., 2010). The COVID-19 pandemic and its associated stay-at-home orders, social distancing, and public safety measures resulted in rapid worldwide implementation of telemedicine for mental health treatment (Arafat et al., 2021; Mansour et al., 2021), including among individuals with attention-deficit/hyperactivity disorder (ADHD; Breaux et al., 2021a). When considering individuals with ADHD, telemedicine takes many forms including assessments, pharmacological consultations, behavioral parent training for parents of children with ADHD, and skills-based and cognitive behavioral interventions for adolescents and adults with ADHD. Prior to the COVID-19 pandemic, only 12 studies had explored the utility of telemedicine for managing ADHD (see Bemanalizadeh et al., 2021 and Spencer et al., 2020 for reviews), with these studies largely focusing on child and adolescent populations. The near universal use of telemedicine during the COVID-19 pandemic has resulted in the number of studies exploring the utility of telemedicine for assessment, psychiatric, and therapy services for individuals with ADHD growing considerably since March 2020, with 24 studies being identified as of February 2022.

Encouragingly, the European ADHD Guidelines Group provided guidance early in the pandemic for the management of ADHD during the COVID-19 pandemic (Cortese et al., 2020), which recommended that all ongoing psychotherapy services continue via telemedicine and advised providing parents with access to online resources in the event that clinician-delivered behavioral parent training be unavailable during the pandemic. Similar guidelines were provided by the Canadian ADHD Resource Alliance (CADDRA 2020), which also discussed how ADHD may be assessed and diagnosed during the pandemic using existing ADHD symptom questionnaires, review of developmental history, collection of collateral information, and completion of functional assessments to gather information remotely. In this chapter, we review the available research on telemedicine procedures for assessing and treating individuals with ADHD and describe the methods and procedures that have been implemented in existing work.

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This research is divided into four contexts: (1) assessments, (2) pharmacological consultation and management, (3) psychosocial and behavioral interventions, and (4) combined pharmacological and behavioral interventions. We end the chapter by highlighting the gaps in our knowledge with suggestions for future research in this area and by providing recommendations for practitioners implementing telemedicine for managing ADHD.

23.1 Telemedicine for Assessment of ADHD

To date, only two manuscripts have examined the use of telemedicine for assessing and diagnosing ADHD: one with children and adolescents (Nelson et al., 2012) and one with adults (Adamou et al., 2021). In the first study, Nelson et al. (2012) conducted a pilot project evaluating whether the ADHD Telemedicine Clinic adhered to the American Academy of Pediatrics guidelines for ADHD evaluations. The study involved families of 22 children (20 males; 36% White; *M*age = 9.3 years) who completed 69 telemedicine visits (22 new intake sessions and 47 follow-up telemedicine encounters) through 18 schools and two health education centers. Clinic procedures involved the school nurse distributing paperwork to the family and school personnel, connecting the child and their family with the clinical team during telemedicine appointments, and assisting the family with recommendations and follow-up after the appointment. The evaluation team included a child psychologist and a developmental pediatrician. They found high adherence rates (95–100%) across the six American Academy of Pediatrics ADHD evaluation guidelines: (1) Evaluate when the child presents with any of the core ADHD symptoms; (2) Use *Diagnostic and Statistical Manual* (DSM) criteria to evaluate ADHD; (3) Use interview and empirically supported scales; (4) Information gathered from multiple informants; (5) Evaluation of comorbidity; and (6) Do not use non-validated diagnostic tools. This study utilized a school-based telemedicine protocol, which allowed for increased communication across the school and mental health system in contrast to traditional face-to-face (F2F) clinics where the school is sometimes not involved or minimally involved throughout the assessment process. As such, it is unclear if adherence to the American Academy of Pediatrics guidelines would differ for telemedicine assessment conducted directly through a clinic rather than the child's school.

In the second study, Adamou et al. (2021) evaluated adult client preferences for the use of telemedicine versus F2F assessment of ADHD and autism spectrum disorder in the context of the COVID-19 pandemic. During their study period, 113 assessments for ADHD and 49 autism assessments occurred via telephone or videoconference. After the assessment, the adults were invited to complete a brief (5 minutes) service user satisfaction survey; a total of 117 adults (93 seeking an ADHD assessment; 78 males; 79% White; 60% age 17–30 years) completed the survey. In terms of ADHD telemedicine assessments, clinic procedures utilized the Diagnostic Interview for ADHD in Adults (Kooij & Francken, 2010), which assesses for DSM symptom criteria and functional impairment in five domains. This interview takes approximately 2 hours to complete and was administered by a range of clinicians (i.e., medical doctors, physician associates, and nurse practitioners) with training in its administration. This study found that the majority (69%) of adults were pleased to receive a remote assessment during the COVID-19 pandemic as an alternative to F2F consultations, with 69% of the sample also indicating that they felt the clinician was able to complete a detailed assessment via telemedicine. In addition, 76% of adults reported that they felt they were able to communicate well during the telemedicine appointment and 69% indicated that they would tell others that this was a good service. However, 62% of the sample indicated that they may have been better able to explain themselves if the appointment was F2F, and 48% indicated a general preference for F2F consultation. Collectively, these results support the general (though not universal) acceptability, feasibility, and reliability of telemedicine to assess for adult ADHD after the COVID-19 pandemic ends; this notion is corroborated by 60% of this sample indicating that telemedicine should be offered as an alternative option post-pandemic.

23.2 Telemedicine for Pharmacological Consultation and Medication Management of ADHD

Two studies have examined telepsychiatry for managing ADHD specifically (Surman et al., 2021; Wenderlich et al., 2021; see below for ten additional studies that examine a combined psychiatry and behavior therapy telemedicine approach). One of these studies focused on a school-based telemedicine program for children (Wenderlich et al., 2021) and one focused on personalized telemedicine using text messaging for pharmacology monitoring among adults with ADHD (Surman et al., 2021). Specifically, Wenderlich et al. (2021) assessed whether school-based telemedicine decreased the number of days to follow-up regarding stimulant medication for newly diagnosed children and adolescents with ADHD and compared rates of 30-day follow-up among in-person versus telemedicine visits. The telemedicine procedures included a four-step process: (1) a telemedicine coordinator called the family the day before a visit to confirm the scheduled time and phone number; (2) a telemedicine technician went to the school and the child was called to the nurse's office, where the vital signs, including height, weight, and blood pressure were measured; (3) the telemedicine clinician and child were then connected over a secure videoconferencing system to discuss current ADHD symptoms, medication effectiveness, and side effects; and (4) after the telemedicine call with the child, the clinician called the child's parent/guardian by telephone to discuss symptoms, side effects, concerns, and potential changes to the treatment plan. During the study period, 852 telemedicine visits, representing 530 children and adolescents, were conducted. Results suggest that rates of follow-up within 30 days significantly increased from 19% to 33% with the school-based telemedicine program, with the telemedicine follow-up visits being significantly more likely than in person follow-up visits (62% versus 32%). Specifically, the average follow-up time significantly decreased from 67 to 34 days. Findings suggest that the school-based telemedicine procedures resulted in increased volume per month (134–160 visits/month), while still reducing the time to follow-up on stimulant medication management after an ADHD diagnosis.

Surman et al. (2021) examined the usability and treatment sensitivity of a text messaging–based pharmacology monitoring among 206 adults (50 males; 77% White; *M*age = 37.3) taking stimulant medications for ADHD. Participants rated an identified ADHD symptom and functional impairment item up to 20 times over a 10-day period (once in the morning, once in the evening). Of note, 79% of participants replied to at least one text message and 22% replied to all 20 text messages. Almost all participants (93%) agreed or strongly agreed that the system was easy to use. Approximately, one-third of participants completed the feasibility questionnaire at the end of the study ($n = 70$). Of these participants, 77% thought it was easy to report on ADHD symptoms and 74% thought it was easy to report on impairment items that were asked by text messaging; 85% of participants reported that it was easier to answer these text message surveys than it would be to keep a paper diary on symptoms for the same length of time. With regard to clinical sensitivity, surveys significantly discriminated between on and off medication states, such that the rates of ADHD symptoms and impairment were significantly lower during periods on medication than during periods off medication—both between days and within the same day. Collectively, these findings suggest that text messaging is a feasible and sensitive means for monitoring responsiveness to pharmacological interventions for adults with ADHD and could be a helpful adjunct to in-person monitoring.

23.3 Telemedicine for Psychosocial or Behavioral Interventions for ADHD

23.3.1 Interventions for Children and Adolescents

There have been eight studies to date that have examined telemedicine approaches to behavior therapy in managing ADHD in children (Corkum et al., 2016; DuPaul et al., 2018; Franke et al., 2020; Reese et al., 2012; Shah et al., 2021; Xie et al., 2013) and adolescents (Breaux et al., 2021b; Sibley et al., 2017). Of these, four examined the efficacy of behavioral parent training (BPT) delivered via telemedicine for children with ADHD (DuPaul et al., 2018; Franke et al., 2020; Reese et al., 2012; Xie et al., 2013).

In the first BPT study, Reese et al. (2012) examined the efficacy of an eight-session group Triple P-Positive Parenting Program that was held via telemedicine to underserved families with a child diagnosed with ADHD. The study involved eight primarily low socioeconomic status families (87.5% White, 12.5% Asian; 71.4% Female; M = 33.8 years) residing in the Appalachian region of Eastern Kentucky, with children ranging in ages between 6 and 10 years (M = 7.6). Although no formal training in telehealth delivery of services was implemented ahead of the program, the licensed psychologist and developmental-behavioral pediatrician both had a significant amount of clinical telehealth experience. Authors reported no major technical difficulties that interfered with service delivery; however, several families were noted to have requested accessing the training solely through the telephone. Authors highlighted the utility of recruitment of families through public schools and the possibility of such recruitment methods to help foster trust and reduce stigma. Overall, families reported large improvements in child behavior and small reductions in parental distress.

In a second BPT study, DuPaul et al. (2018) piloted a randomized controlled trial evaluating parent engagement and program acceptability of F2F and telemedicine BPT for parents of preschool-aged children (3–5 years old) at the risk for developing ADHD. Parents were recruited for participation in a 10-session Project Promoting Engagement with ADHD Pre-Kindergartners (PEAK; DuPaul et al., 2018). One hundred families expressed initial interest in participating in Project PEAK. After eligibility screening and scheduling, 47 families with preschool children (30 boys) were recruited to participate in cohorts of 10–14 families. Families were randomly assigned to either participate in the F2F program (n = 16), the telemedicine BPT program (n = 15), or to be placed in the waitlist control group (n = 16) to receive the telemedicine program after the post-treatment assessment phase. All participants met DSM-5 criteria for ADHD, with the majority displaying combined presentation (61.7%) and about half of the participants (53.2%) also meeting the criteria for oppositional defiant disorder (ODD). Each of the treatment groups (F2F and telemedicine BPT) received identical content, materials, and information during the sessions. Parents were provided information in session via lecture, group discussion, role-play, brief quizzes, and videos. Group assessment data were collected at three different time points, pre-, mid-, and post-treatment. The F2F and telemedicine BPT programs both had relatively high rates of engagement by parents (M = 80% attendance of treatment sessions) with no difference across groups and moderate acceptability. However, parents in the F2F group reported significantly higher acceptability ratings than parents in the telemedicine BPT group. Both intervention formats resulted in significantly higher parent knowledge of intervention procedures, significantly lower parent stress, significantly higher treatment fidelity (i.e., parent implementation of prescribed techniques), and significantly less child behavior problems compared to the waitlist control, with no significant difference between the F2F and telemedicine programs.

In another randomized control trial involving telemedicine delivery of BPT, Franke et al. (2020) evaluated the efficacy of an online self-help program, Triple P Online (TPOL; Turner & Sanders, 2011) in a sample of parents of preschoolers with ADHD symptoms in New Zealand. TPOL is an online positive parenting program that is self-directed and interactive, with this specific program for the study being an adapted version from Level 4 of the Triple P-Positive Parenting Program (Sanders, 2008; Franke et al., 2020). The program consists of eight sequenced modules including audio-visual representation of information and interactive exercises, which are designed to actively engage users, further knowledge, and increase parental self-regulation. Two consultation calls with a Triple P facilitator were incorporated into the program to help parents with tailoring implementation of parenting strategies to their specific family situation, to problem-solve any parenting strategy implementation problems, and to enhance the likelihood of completing the program. Participants included 53 parents with a 3- to 4-year-old child with elevated and impairing levels of ADHD symptoms. Seventeen of the families had a parent with clinically elevated levels of ADHD symptoms as well. The study assessment phase took place at three time points: pre-intervention (T1), post-intervention (T2; 3 months after T1), and 6-month follow-up (T3). After completing the T1 assessment phase, families were randomly assigned to the intervention or the delayed intervention group, which received the intervention after T3 assessment. Participants in the TPOL group received access to the program for 16 weeks, with parents being able to complete the intervention at their own pace. In terms of utilization of the TPOL, 55% of families completed all eight modules, 15% completed 6 or 7 modules, 22% completed 3–5 modules, 4% completed 1 or 2 modules, and 4% did not complete any modules. Satisfaction was high for TPOL ($M = 44.63$ on an 8 to 56-point scale). With regard to treatment efficacy, TPOL resulted in a significant decrease in mother-rated child hyperactivity/inattention, restlessness/impulsivity, defiance/aggression, and significant improvement in mother-rated social functioning and teacher-rated prosocial behavior, relative to the delayed intervention group. In addition, mothers in TPOL reported greater reductions in over-reactivity, verbosity, laxness, stress, and depression, and greater increases in positive parenting, parenting satisfaction, and parenting self-efficacy, relative to the delayed intervention group. Many of these treatment effects were maintained at the 6-month follow-up.

In the final BPT randomized controlled trial, Xie et al. (2013) examined the effectiveness of a group BPT for parents of children with ADHD ages 6–14 years ($M = 10.4$), delivered via videoconferencing (telemedicine group; $n = 9$) or F2F sessions ($n = 13$). The intervention consisted of 10 sessions of weekly BPT groups held either via telemedicine or F2F delivery and were conducted using a manualized treatment. In addition, though not mandatory, a skills training and homework group was offered to the children of both groups while parents attended the BPT group, which also provided childcare for the parents while they were in training sessions for the F2F condition. Results demonstrated that telemedicine delivery of BPT is as acceptable to parents and is perceived as equally as useful as the F2F groups. In addition, the telemedicine and F2F groups were found to be as effective at reducing child inattentive, hyperactive, ODD, conduct, and anxiety symptoms, with some evidence that the telemedicine group resulted in larger improvements in hyperactivity than the F2F group.

The remaining four telemedicine interventions for children and adolescents with ADHD included a telephone coach support insomnia intervention (Corkum et al., 2016), a skills-based parent–teen therapy via videoconferencing (Sibley et al., 2017), a text message–based intervention during the COVID-19 pandemic (Shah et al., 2021), and a comparison of an in-person versus telemedicine delivery of a group-based intervention targeting emotion dysregulation and family conflict for families of adolescents with ADHD (Breaux et al., 2021b).

First, Corkum et al. (2016) conducted a randomized controlled trial to evaluate the Better Nights/Better Days intervention for insomnia in school-aged children with and without ADHD, to determine its effectiveness on children's sleep and psychosocial functioning. The intervention included five sessions delivered via a written manual provided to parents; parents were directed to complete one session per week with weekly 30–45 minutes telephone support by a paraprofessional coach. Participants included 61 children between the ages of 5 and 12 years who had experienced difficulties with falling asleep (i.e., 25 minutes or more of sleep onset latency), with or without bedtime resistance, for a duration of >1 month with impairment to daily functioning. Participants were randomized into either the intervention group ($N = 30$; *M*age = 108.0 months; $SD = 23.65$; 51.6% female) or the waitlist control group ($N = 31$; *M*age = 110.60 months; $SD = 23.72$; 53.7% female), and parents completed questionnaire administered over the phone at baseline, post-intervention (2 months), and follow-up (6 months). Results demonstrated that the Better Nights/Better Days intervention had very high satisfaction ratings and resulted in significantly improved sleep outcomes and significant decreases in internalizing and externalizing problems from baseline to post-intervention relative to the waitlist control group. ADHD status did not relate to treatment effects or satisfaction ratings.

In a preliminary feasibility study by Sibley et al. (2017), the authors evaluated a telemedicine approach for disseminating parent–teen therapy for parents and their teens with ADHD ($N = 20$). In this study, teens and parents received an evidence-based dyadic therapy, Supporting Teens' Autonomy Daily (STAND), which incorporates skills-based modules with motivational interviewing delivered over a videoconferencing format to target key adolescent functional domains (i.e., academic and family impairment). STAND consists of 10 manualized 60-minute family therapy sessions attended by the parent and teen. Participants included 20 adolescents with ADHD (11–16 years; $M = 13.9$; 75% male; 50% white). The majority (85%) of families completed all 10 sessions, among the families that completed all 10 sessions, home activity completion was high ($M = 70.3\%$). A decent amount of technological disturbances (e.g., Internet connection problems, temporarily losing audio; M number of sessions with interruptions = 2.4) and home disturbances (e.g., family member leaving the room, a non-participated family member entered the room; M number of sessions with interruptions = 3.6) occurred. Despite this, therapists believe that the videoconferencing format enhanced treatment for 50% of families due to fewer cancellations, better fitting the family's schedule, overcoming distance from the clinic, and beginning sessions on time. High fidelity (81.9%) and adherence to the motivational interviewing framework were observed. Therapeutic alliance and treatment satisfaction were reported as acceptable and key mechanisms of change were engaged (i.e., adolescent motivation to meet goals, parent strategy implementation). Lastly, the telemedicine STAND intervention resulted in significant reductions in parent- and teacher-reported inattention and organization, time management, and planning problems.

Third, Shah et al. (2021) examined the use of a text message–based intervention completed over 2 weeks with families of children with ADHD under lockdown. The text message intervention included six messages delivered at a frequency of three messages per week for 2 weeks. The text messages included the information covering areas of identifying and managing problematic behaviors of the child during lockdown, use of contingency management with the child, positive parenting principles such as constituency, effective communication skills like reducing critical comments and using clear and specific instructions, time out strategies, how to handle increased media use, and how to increase effective and supervised screen use. In addition to the text message–based intervention, clinicians provided reading materials and an option of consultation via telephone. Participants included 41 families of children with ADHD (*M*age = 9.8; 89.6% male) who agreed to receive the intervention; however, only 29 participants responded to the satisfaction survey. The majority of participants reported going through most of the messages (89.7%) and almost all (96.6%) considered the messages to be an adequate length. Moderate ratings were provided for the content, usefulness, and satisfaction with the text messages; however, these ratings were not correlated with child behavior problem severity, and only half of the participants (55.2%) reported that the text messages were useful in managing child ADHD in a better way. Only six parents sought telephone consultations. When asked how the text message–based intervention could be improved, parents reported that having a more individually focused text message system based on specific symptoms or age-specific interventions would be helpful. In addition, parents suggested the use of audio-video interactive sessions, more activities, and more frequent information.

Finally, Breaux et al. (2021b) evaluated the feasibility, acceptability, and efficacy of a group-based intervention targeting emotion dysregulation and interpersonal conflict, Regulating Emotions Like An eXpert (RELAX), in a sample of adolescents diagnosed with ADHD, delivered in-person and via telemedicine groups. RELAX consists of eight weekly 90-minute groups, with caregiver and adolescent sessions being held separately for the first 60 minutes and the last 30 minutes consisting of a combined problem-solving/discussion activity among the caregiver–adolescent dyads. The content of the RELAX intervention was the same for F2F and telemedicine groups, but sessions were delivered via the use of two separate HIPAA compliant Zoom links for the telemedicine, with one for the adolescent groups and one for the caregiver groups. After the first 60 minutes, caregivers joined the adolescent Zoom link for a combined session during the last 30 minutes of each group session. The breakout room feature on Zoom was used in the separate caregiver and adolescent groups to facilitate discussion and encourage equal participation. In addition, it was also used during the combined sessions so each adolescent–caregiver dyad could be in their own room, with clinicians available to help facilitate discussion compliance, problem-solve, and create a tangible and specific plan for the coming week that was unique to each family's needs. Participants included 32 families (18 in-person and 14 telehealth) of adolescents diagnosed with ADHD (ages of 11–16 years; $M = 13.6$, 22 males). Attendance was higher for telemedicine than in-person (95% versus 87%), but homework completion was higher for in-person relative to telemedicine (85% versus 70%). Caregiver and adolescent feedback indicated very high rates of satisfaction with RELAX, with no significant differences in caregiver satisfaction and minimal differences in adolescent satisfaction between the in-person and telemedicine groups. Treatment outcomes (i.e., large improvements in adolescent emotion dysregulation and family conflict, moderate improvements in emotion socialization parenting practices, and small improvements in parent emotion dysregulation) across in-person and telemedicine were similar, with some evidence for larger improvement of adolescent emotion dysregulation for telemedicine, but larger improvements for family conflict for the in-person intervention.

23.3.2 Interventions for Adults

Two studies have examined telemedicine approaches to behavior therapy in managing adult ADHD (Fullen et al., 2020a; Oddo et al., 2021). Both of these studies focused on emerging adults with ADHD during the COVID-19 pandemic and associated lockdowns in 2020. In the first study, Fullen et al. (2020a) explored the outcomes of an open trial of a remotely delivered manualized form of Acceptance and Commitment Therapy to 12 adults with ADHD (median age = 21.9). The telemedicine Acceptance and Commitment Therapy involved three sessions delivered either over the phone or via videoconferencing, with each session ranging from 45 to 90 minutes. Attrition was low (<8%), indicating good treatment acceptability and feasibility. Participants displayed statistically and clinically significant improvements in self-reported mood, anxiety, and psychosocial adjustment.

The second study was conducted by Oddo et al. (2021), which examined the feasibility, acceptability, and engagement of implementing the Students Understanding College Choices: Encouraging & Executing Decisions for Success (SUCCEEDS; Meinzer et al., 2020) intervention delivered via telemedicine to college students with ADHD during the COVID-19 pandemic. SUCCEEDS follows a comprehensive model of care for students with ADHD, with students receiving individual and group sessions designed to target psychological comorbidity, academic problems, and family conflict/accommodation over the course of a semester. Participants included SUCCEEDS supervisors ($n = 2$; 50% female), group leaders ($n = 2$; 100% female), coaches ($n = 12$; 91% female), and students enrolled during the spring of 2020 ($n = 6$; 16% female) and fall of 2020 ($n = 4$; 0% female) academic semesters, who provided qualitative feedback on the telemedicine SUCCEEDS intervention. The authors discussed legal considerations (e.g., inability to practice across state lines), safety considerations (e.g., management of suicide risk or substance abuse concerns), and supervision considerations (e.g., frequency and individual versus group format of supervision) for telemedicine. In addition, they discussed changes made to SUCCEEDS to be most helpful to participants, particularly in light of COVID-19-related restrictions. Specifically, SUCCEEDS coaches created daily checklists that incorporated SUCCEEDS content (e.g., waking up at a predetermined time, taking medication, breaking tasks into smaller components) for participants to complete and return via email each day. These checklists were sent out via an automatic email each morning. In addition, instead of having weekly 60-minute individual meetings, most participants preferred having 2–3 brief meetings weekly; participants were able to work with their coaches to select a meeting format that worked best with their goals. Finally, they highlighted the benefit of telemedicine for facilitating opportunities for in vivo practice to improve skill and strategy use in-the-moment (e.g., desk organization). In terms of feasibility and acceptability, a significant drop in attendance was noted from the spring of 2020 in-person sessions pre-COVID-19 lockdown (75%) to the telemedicine sessions (20% and 37%). However, attendance was significantly improved, with 100% adherence by the fall of 2020 groups. The authors attributed this improvement to setting clear expectations to attend groups, having regular weekly group meetings, and limiting the meetings to 50 minutes (with a 2-minute break) to maximize attention.

23.4 Telemedicine for Combined Pharmacological and Behavioral Interventions for ADHD

To date, ten studies have examined a combined psychiatry and behavior therapy telemedicine approach to managing ADHD (Hohman et al., 2020; McCarty et al., 2015; Myers et al., 2013, 2015; Rockhill et al., 2016, 2020; Tse et al., 2015; Vander-Stoep & Myers, 2013; Vander-Stoep et al., 2017; Wyler et al., 2021). Although each of these studies focused on distinct research questions and lines of inquiry, eight of these studies used data from the Children's ADHD Telemental Health Treatment Study (CATTS). CATTS is a 5-year randomized control trial intended to evaluate the efficacy of telemedicine treatment in the medical care of children with ADHD (ages 5.5–12 years), living in underserved areas with limited access to evidence-based treatment options. A total of 223 children diagnosed with moderate to severe levels of ADHD were randomly assigned to either an experimental ($n = 111$) or comparison group ($n = 112$). The comparison group received an Augmented Primary Care (APC) service model of treatment, which consisted of a single telepsychiatry consultation session, including the provision of treatment recommendations and referrals to primary care physicians (PCP) to implement at the discretion of the family. The experimental group received telemedicine treatment, which included a combination of pharmacotherapy and caregiver behavior training administered online by psychiatrists and therapists. This telemedicine treatment took place over 25 weeks and included 6 sessions spaced 3–4 weeks apart, with the pharmacotherapy and caregiver behavior training being delivered back-to-back during each session. With regards to medication decision-making, telepsychiatrists individualized medication treatment based on the presence of any comorbidities and used measures of symptom change to guide decisions about continuing or modifying treatment. At baseline, and at weeks 4, 10, 19, and 25, measurements of child ADHD-related behaviors were obtained from parents and teachers along with measures of overall functional impairment and perceived caregiver stress.

In the first CATTS manuscript, Vander-Stoep and Myers (2013) reported on challenges in conducting a telemedicine clinical trial and lessons learned in conducting CATTS. The authors noted four primary challenges: designing the research and intervention approach given limited prior literature, recruiting and retaining participants, providing evidence-based interventions to distant sites including coordination of telepsychiatrists and therapists, and coordinating research activities. Despite these challenges, they highlighted that telemedicine provided a viable means for providing pharmacological and behavioral training services to families of children with ADHD. Second, Myers et al. (2013) evaluated the feasibility of using telemedicine for children with ADHD in an effort to provide stronger research evidence for using telemedicine as an effective service delivery model. Specifically, the authors examined the ability to recruit families from hard-to-reach sites for such a trial, the capability to retain participants in the experimental and comparison groups, and the ability to ensure the completion of outcome measures by families living in distant communities. Over the course of the 5-year study, a total of 530 youth was referred to the clinical trial by 150 PCPs from different remote communities; out of these, 223 children and caregivers were deemed eligible to participate. The trial also demonstrated high rates of participant retention with families in the experimental group attending an average of 5.3 out of 6 possible sessions and 96% of families in the comparison group attending the single teleconsultation session. Fidelity for both telepsychiatry (92.6% for the experimental group and 89.3% for the APC group) and therapy (94.2%) was excellent. Finally, high rates of caregiver satisfaction were reported (*M* of 38, out of 40) and high rates of research assessment completion were also recorded for caregivers and teachers (96% and 100%, respectively). The third CATTS study, conducted by McCarty et al. (2015), also examined the acceptability, feasibility, and fidelity of CATTS. The authors reported the same high rates of attendance, caregiver satisfaction, and telepsychiatrist and therapist adherence as Myers et al. (2013), but they provided more information on the changes made by telepsychiatrists during the study (e.g., changing the dose of an existing medication) and also reported therapist feedback. Therapists reported that the intervention increased their knowledge and skills in working with ADHD and that they received sufficient training and supervision to deliver the intervention; therapists were split regarding their preference for individual versus group supervision. In addition, they found high rates of correct answers on Caregiver Behavioral Training quizzes (88% for medication neurobiology and 90% for behavioral training).

The efficacy of the CATTS telemedicine relative to APC was examined by Myers et al. (2015). Although children in both groups improved, children assigned to the CATTS telemedicine group improved significantly more than the APC group for parent-reported inattention, hyperactivity, total ADHD, ODD, and impairment in addition to teacher-reported hyperactivity and total ADHD. Vander-Stoep and colleagues (2017) also examined the efficacy of the CATTS telemedicine intervention relative to APC but focused on evaluating the differences in outcomes for caregivers. Similar to child outcomes, the caregivers in both groups improved, but caregivers in the CATTS telemedicine service delivery model exhibited significantly greater reductions in parenting stress, caregiver strain, and depressive symptoms and significantly larger increases in family empowerment relative to the comparison APC service model. Furthermore, these effects on caregiver outcomes were mediated by improvements in child ADHD symptoms.

Rockhill et al. (2016) investigated the different strategies that telepsychiatrists used to prescribe medication in the CATTS trial. Two strategies were used for medication decision-making by psychiatrists, namely, the Texas Children's Medication Algorithm Project (TCMAP) and a treat-to-target model to titrate medication dosage. The TCMAP algorithm provides a way to track the adherence of telepsychiatrists to the protocol for prescribing medication. It includes five algorithms: (1) ADHD alone; and ADHD with comorbidities of (2) anxiety, (3) depression, (4) tics, or (5) aggression. The telepsychiatrists used this algorithm to guide their choice of the prescribed medication with the option of changing their course of treatment at any time. Second, telepsychiatrists used a treat-to-target model for medication management to reach a predetermined goal of achieving a 50% reduction in ADHD-related symptoms. High fidelity was observed in telepsychiatrists' use of the TCMAP algorithms for medication management. In addition, telepsychiatrists in the CATTS telemedicine group demonstrated 46% attainment of the predetermined goal, while this attainment was only 13.6% for the APC comparison group.

In 2020, Rockhill and colleagues conducted a short-term, 10-week follow-up with the 223 families that participated in the CATTS to determine the "after-effect" of the two service models on PCPs' assertiveness in managing ADHD during the trial and the 10-week follow-up. The telemedicine service model resulted in more assertive ADHD management relative to the APC service model, including a greater number of visits for ADHD treatment (7.1 versus 3.4) across the entire 32-week period, greater likelihood of taking an ADHD medication during follow-up (82% versus 61%), and a higher stimulant dosage at 32 weeks.

Utilizing a subsample of 37 children and caregivers who participated in the CATTS, Tse et al. (2015) evaluated the utility of teleconferencing as a means for delivering behavioral interventions to families of children with ADHD. Specifically, this study evaluated differences in outcomes between 12 families who received caregiver behavior training via telemedicine and 25 families who received the same intervention in-person. Overall, high attendance (*M* number of sessions = 5.8 for telepsychiatry and 5.6 for telemedicine caregiver training sessions; 5.7 for in-person psychiatry and 5.5 for in-person caregiver training sessions) and satisfaction rates (*M* = 36.5 for telemedicine, 38.6 for in person out of 40) were observed and did not differ across telemedicine versus in-person care. Similarly, therapists demonstrated good adherence to the intervention manual, with the same therapist exhibiting 93% adherence during telemedicine and 96% adherence in person. With regards to treatment outcomes, children in both groups improved significantly in ADHD and ODD symptoms, and functional impairment in general. In contrast, significant improvements in parenting stress, caregiver strain, and family empowerment were observed for the in-person group but not the telemedicine group. However, it should be noted that means were all in the expected direction, so the lack of a significant improvement may reflect the study being underpowered to detect smaller effects with a sample size of 12 for the telemedicine group.

Beyond these CATTS manuscripts, two additional studies examined the utility of telemedicine for psychiatry and psychosocial interventions for adults with ADHD (Hohman et al., 2020; Wyler et al., 2021). First, Hohman et al. (2020) conducted a retrospective, cross-sectional review of all ADHD encounters on the American Well DTC telemedicine platform from July 2016 to July 2018. Notably, the volume of ADHD encounters increased by over 500% from 2016 (50 encounters) to 2018 (294 encounters). A total of 618 encounters for ADHD occurred during this 2-year period for 307 total patients (55.4% male). The majority (73.3%) of patients only had one telemedicine visit during the study period; however, 46.5% of patients who sought therapy had ≥1 follow-up encounters. Of the 618 total encounters, 40.0% were with therapists and 44.3% were with psychiatrists; 15.7% of visits occurred with non-behavioral health providers. The majority of patients (55.7%) accessed the telemedicine platform during evenings or weekends, suggesting that telemedicine can expand the hours in which patients are treated. Wait time was very brief, with a median of 2.6 minutes. The median visit length was 48 minutes for therapy and 18 minutes for psychiatry. Of the encounters, 43.7% resulted in a prescription, most frequently atomoxetine (19.5%), bupropion (23.5%), or an antidepressant (27.1%); of note, no controlled substances were prescribed. Importantly, high satisfaction was observed across encounters (i.e., *M* of 4.9 out of 5).

Finally, a study by Wyler et al. (2021) explored differences in patient and clinician experiences during treatment for adults with ADHD across three different settings during the COVID-19 pandemic—F2F with the therapist wearing a mask, via telephone, and via videoconferencing. Two therapists and 60 patients (*M*age = 39.1 years; 55% male) receiving treatment at an outpatient clinic participated in the study, half of whom received treatment in-person and half of whom received treatment remotely. Results demonstrated that the telemedicine group had significantly higher attendance rates compared to the in-person group. There were no significant differences in levels of satisfaction, therapeutic alliance, post-session positivity, and session flow/smoothness when patients received treatment in-person versus via telemedicine. However, the telemedicine sessions were rated as being significantly less "deep" than the in-person sessions. Importantly, the videoconference group reported more depth to their sessions with more sessions that they had in that modality, suggesting that as patients adapt to the new telemedicine format this difference may disappear. Finally, participants in the telemedicine group were split regarding their reported preference for telemedicine versus in person treatment, with approximately half reporting a preference for each; there was a clear preference for videoconferencing over the telephone however within the field of telemedicine.

23.5 Summary of the Existing Telemedicine Literature for Managing ADHD

In the broader telemedicine literature, prior research suggests similar outcomes for telemedicine relative to in-person interventions (see Anderson & Titov, 2014), with growing evidence of the effectiveness and acceptability of self-administered telemedicine interventions (e.g., Moritz et al., 2012; Richards et al., 2013). Notably, telemedicine is more cost effective, reduces mental health inequalities, and reduces the stigma surrounding mental health treatment (Alvarez-Jimenez et al., 2016; Anderson & Titov, 2014). However, prior to the COVID-19 pandemic, telemedicine was available and paid for by Medicare, Medicaid, and private insurance companies only for people living in areas where it was hard to access the required licensed professional; additionally, it required patients to go to a special clinic for a telemedicine visit to access HIPAA-compliant video equipment (CHADD, 2020). Encouragingly, the pandemic has resulted in the relaxing of these and other restrictions for the use of telemedicine for mental health services. The relaxing of these restrictions and the necessity of telemedicine due to social distancing guidelines and stay-at-home orders have resulted in 24 peer-reviewed publications to date examining the utility of telemedicine for managing ADHD specifically (see Neufeld et al., 2007 and Yellowlees et al., 2008, for examples of telemedicine programs for mental health populations broadly). These studies are summarized in Table 23.1.

Consistent with the larger telemedicine literature, rates of utilization of telemedicine services for managing ADHD appeared to be on the rise prior to the COVID-19 pandemic (Hohman et al., 2020). Additionally, across the telemedicine studies for individuals with ADHD reviewed in this chapter, researchers found generally high levels of treatment fidelity, client and clinician satisfaction, acceptability of telemedicine services, therapeutic alliance, and treatment efficacy. Importantly, better attendance was observed via telemedicine than in person for several studies (Breaux et al., 2021b; Wyler et al., 2021), suggesting that the removal of barriers such as childcare and transportation and increased flexibility in scheduling (e.g., night and weekend appointments) that telemedicine provides (Hohman et al., 2020) may result in greater utilization of services for ADHD. However, better attendance was not a universal finding, especially in light of the COVID-19 lockdown and early disruptions to regular weekly sessions (Oddo et al., 2021).

With regard to treatment outcomes, almost all studies found comparable benefits for telemedicine relative to in-person, though a couple of studies also found some evidence for larger

Table 23.1 Telemedicine research with individuals with ADHD

Authors	Population	Telemedicine type	Sample size	Description of telemedicine type
Adamou et al. (2021)	Adults	Assessment	117 (93 with ADHD)	Assessments for ADHD and Autism
Breaux et al. (2023)	Adolescents	Therapy	32	Regulating Emotions Like An eXpert (RELAX) Intervention
Corkum et al. (2016)	Children	Therapy	61	Intervention for Insomnia
DuPaul et al. (2018)	Children	Therapy	47	Behavioral Parent Training
Franke et al. (2020)	Children	Therapy	53	Behavioral Parent Training
Fullen et al. (2020a, b)	Adults	Therapy	12	Acceptance and Commitment Therapy
Hohman et al. (2020)	Adults	Psychiatry and Therapy	307	Retrospective review of ADHD encounters on the American Well DTC telemedicine Platform
McCarty et al. (2015)	Children	Psychiatry and Therapy	223	Combination of Medication Management and Behavioral Parent Training
Myers et al. (2013)	Children	Psychiatry and Therapy	223	Combination of Medication Management and Behavioral Parent Training
Myers et al. (2015)	Children	Psychiatry and Therapy	223	Combination of Medication Management and Behavioral Parent Training
Nelson et al. (2012)	Children	Assessment	22	School-based Telemental Health Protocol connecting families with a child psychologist and developmental pediatrician
Oddo et al. (2021)	Adults	Therapy	10	Students Understanding College Choices: Encouraging & Executing Decisions for Success (SUCCEEDS)
Reese et al. (2012)	Children	Therapy	8	Behavioral Parent Training
Rockhill et al. (2016)	Children	Psychiatry and Therapy	223	Examined Prescribing Strategies of Telepsychiatrists
Rockhill et al. (2020)	Children	Psychiatry and Therapy	223	Combination of Medication Management and Behavioral Parent Training
Shah et al. (2021)	Children	Therapy	29	Text Message-Based Intervention with Reading Materials and an Optional Telephonic Consultation
Sibley et al. (2017)	Adolescents	Therapy	20	Supporting Teens' Autonomy Daily (STAND)
Surman et al. (2021)	Adults	Psychiatry	206	Text Message-Based Pharmacology Monitoring
Tse et al. (2015)	Children	Psychiatry and Therapy	37	Psychiatry and Therapy
Vander Stoep and Myers (2013)	Children	Psychiatry and Therapy	223	Examined Prescribing Strategies of Telepsychiatrists
Vander Stoep et al. (2017)	Children	Psychiatry and Therapy	223	Combination of Medication Management and Behavioral Parent Training
Wenderlich et al. (2021)	Children	Psychiatry	530	School-Based Telemedicine to Follow Up on Prescribed Stimulant Medication
Wyler et al. (2021)	Adults	Psychiatry and Therapy	60	Compared experiences of combined pharmacological therapy and psychotherapy delivered face-to-face with the therapist wearing a face mask, via telephone, or via videoconferencing
Xie et al. (2013)	Children	Therapy	22	Behavioral Parent Training

Note. ADHD attention-deficit/hyperactivity disorder improvements for certain outcomes for the telemedicine groups (Breaux et al., 2021b; Xie et al., 2013). Studies also highlighted that telemedicine provided better insight into the natural home environment and opportunities for in vivo skill rehearsal relative to in person interventions (Oddo et al., 2021). However, it is important to note that many of the studies to date have been pilot or feasibility studies with small sample sizes. Specifically, only 11 studies included sample sizes over 100 (range = 117–530), with seven of these coming from the same larger study (i.e., CATTS). Another 10 of the studies had sample sizes smaller than 50 (range = 8–47), and three had sample sizes between 50 and 100.

In contrast to these strengths and benefits of telemedicine, there was some evidence for higher acceptability of in-person interventions relative to telemedicine (e.g., DePaul et al., 2018) or preference for in-person services (e.g., Adamou et al., 2021). In addition, several challenges of implementation were also identified across studies. These include difficulties with recruiting participants remotely, poor Internet connections for videoconferencing resulting in temporary disconnection during treatment, privacy and legal concerns (e.g., home disturbances such as someone outside of the family entering the room), safety concerns such as suicide risk, lower homework completion than in-person interventions, and patients feeling that sessions were not as "deep" via telemedicine (Breaux et al., 2021b; Oddo et al., 2021; Sibley et al., 2017; Vander Stoep & Myers, 2013; Wyler et al., 2021). It should be noted, however, that technical issues were not universally reported across studies (e.g., Reese et al., 2012 reported no major technical difficulties) and rates of homework completion/adherence were still high. Finally, although there was overwhelming evidence for the efficacy of telemedicine interventions, one study failed to find significant improvements in parent outcomes for the telemedicine group, but did find improvements for parent outcomes with the in-person group (Tse et al., 2015); child outcomes were observed across both modalities.

23.6 Gaps in Our Knowledge and Recommendations for Future Research

23.6.1 Telemedicine for Adult ADHD

Consistent with ADHD being viewed primarily as a disorder of childhood until recently and the underdiagnosis of adult ADHD (Kooij et al., 2010), the majority of telemedicine studies have been conducted with child and adolescent populations. Specifically, to date, we found only one assessment, one psychiatry, two behavioral intervention, and two combined pharmacological and behavioral intervention studies for adults with ADHD. These studies provide preliminary support for the acceptability and feasibility of assessing adult ADHD via telemedicine (Adamou et al., 2021), the feasibility of using telemedicine for pharmacological monitoring among adults with ADHD (Surman et al., 2021), and the feasibility and acceptability of telemedicine to deliver pharmacological and psychosocial interventions for adult ADHD (Hohman et al., 2020; Wyler et al., 2021). Although the assessment and psychiatry or combined telemedicine services included a broad age range of adults, the behavioral intervention studies (Fullen et al., 2020a; Oddo et al., 2021) both focused on the emerging adult developmental period (i.e., adults ages 18–25); as such, it is unclear whether interventions for adults with ADHD more broadly may be effective via telemedicine. Although medication is a first-line treatment for adult ADHD, there is promising evidence for psychological treatments, particularly Cognitive Behavioral Therapy in adult ADHD (see Fullen et al., 2020b for a review), including evidence that targeting parent ADHD through BPT or a combination of BPT and medication results in improved child outcomes (e.g., Chronis-Tuscano et al., 2011, 2020) for in-person interventions. As such, exploring the feasibility and efficacy of such interventions delivered via telemedicine, particularly outside the context of the COVID-19 pandemic, will be an important area for future research.

23.6.2 Assessment of ADHD Via Telemedicine

Only two studies to date have examined the utility of telemedicine for the assessment of ADHD, limiting meaningful conclusions from being drawn at this time, particularly in light of the limitations of these two studies. Specifically, although Nelson et al. (2012) was a highly novel and strong study, they focused on adherence to the American Academy of Pediatrics guidelines for ADHD evaluations rather than on outcomes that may provide more meaningful insight into the utility of telemedicine for assessment of ADHD (e.g., time until diagnosis, number of patients able to be assessed, accuracy of diagnosis, and acceptability to patients). Additionally, since this study was conducted through a school-based telemedicine protocol, it is unclear what the feasibility, acceptability, and efficacy of clinic-based telemedicine procedures for assessing ADHD in children and adolescents would be. This is a critical area for future research.

Similarly, although Adamou et al. (2021) assessed client preference and acceptability of remote assessment during the COVID-19 pandemic, it is unclear how accurate these diagnoses are, and if a larger number of patients were assessed (or if patients who would not otherwise have been assessed were able to receive an assessment thanks to telemedicine), rather than it reflecting a temporary solution during the pandemic. This study also relied solely on adult self-report; however, recommendations from the American Academy of Family Physicians' Adult ADHD Toolkit suggest gathering of ratings from parents, spouses, or another informant for current functioning and parent report for functioning in childhood (Adult ADHD Toolkit, 2022). Assessing adult ADHD is challenging, relative to assessing other mental health disorders or age groups (Lovett & Davis, 2017), with many clinicians reporting a lack of confidence in their clinical judgment in determining ADHD diagnoses in adults under typical conditions (Schneider et al., 2019). In particular, clinicians report that they rarely can ensure all diagnostic criteria have been met prior to making a diagnosis, particularly in emerging adults (Nelson & Lovett, 2019; Weis et al., 2019). As such, this is an important area for future research to further explore before telemedicine is used routinely to assess adult ADHD.

23.6.3 Factors That May Impact Efficacy of Telemedicine

Pharmacological and behavioral interventions differed significantly in terms of the frequency/dosage and format delivered via telemedicine. For example, several studies only utilized text messaging (Shah et al., 2021; Surman et al., 2021), others used telephone (e.g., Wyler et al., 2021), whereas others used videoconferencing (e.g., Sibley et al., 2017). Within behavioral interventions or combined behavioral and pharmacological interventions, session numbers ranged from 3 sessions (Fullen et al., 2020a, b) to 6 sessions over 22 (the CATTS manuscripts) to 10 weekly sessions (DuPaul et al., 2018; Sibley et al., 2017; Xie et al., 2013) to two to three brief weekly check-ins (Oddo et al., 2021). Furthermore, some of these telemedicine studies only focused on symptom monitoring/responsiveness to intervention (Surman et al., 2021), whereas others provided generic resources related to ADHD (Shah et al., 2021), and others provided direct, individualized interventions (e.g., Breaux et al., 2021b; Oddo et al., 2021). Similarly, some interventions were self-paced entirely or with a couple of consultations (e.g., Corkum et al., 2016; Franke et al., 2020), whereas others were clinician administered (e.g., Breaux et al., 2021b; Sibley et al., 2017). It is highly likely that such differences would lead to differences in the impact of such telemedicine services on treatment outcomes.

For example, the current studies indicated a 55% completion of all treatment content for a self-paced intervention (Franke et al., 2020) versus 95% attendance at sessions for a clinician-led intervention (Breaux et al., 2021b). Additionally, participants in the CATTS trial who received the six sessions of combined pharmacological and behavioral therapy had better child and parent outcomes than participants who only received a single telepsychiatry consultation session. Similarly, participants in the Shah et al. (2021) study (which utilized six generic text messages over 2 weeks) indicated a preference for more frequent and individually focused content, and participants in the Wyler et al. (2021) study indicated a preference for videoconferencing over telephone delivery. Given the small number of studies to date and the heterogeneity (e.g., interventions targeting ADHD symptoms specifically versus other related impairments like insomnia or emotion dysregulation) across studies, it is premature to systematically explore these factors. However, this is a critical area for future research.

Studies also differed on where telemedicine service delivery was coming from. For example, several studies utilized recruitment, assessment, or intervention systems through schools (Nelson et al., 2012; Reese et al., 2012; Wenderlich et al., 2021). Encouragingly, findings suggested that school-based telemedicine delivery increased the rate of families following up within 30 days for pharmacological care and increased the volume of visits/month. Additionally, this delivery format enables greater contact across school and mental health systems relative to traditional in-person assessment and therapy. As such, it will be critical for future research to explore if such school involvement leads to more accurate or timely diagnoses and better treatment outcomes. Finally, in addition to intervention factors that may impact efficacy, individual factors such as client preference for telemedicine versus in-person service, barriers to in-person care, and age will be important for future research to explore.

23.7 Recommendations and Considerations for Practitioners Implementing Telemedicine for Managing ADHD

Despite these gaps in the literature, three recommendations for practitioners regarding implementation of telemedicine for managing ADHD arose from the current review. First, practitioner training in the use of telemedicine is important. Only a handful of studies reviewed in this chapter formally provided training in the use of telemedicine for the practitioners in their study. This may be reflective of the growing comfort with utilizing telecommunication, particularly in light of the COVID-19 pandemic. However, we strongly advise practitioners to receive training (e.g., American Psychological Association, 2021) and familiarize themselves with guidelines set forth by national agencies and ethics committees regarding the safe delivery of telemedicine (e.g., CADDRA, 2020). In particular, as was highlighted by several of the studies reviewed in this chapter, it is critical that practitioners are aware of the ethical and safety concerns (e.g., client privacy, risk assessments for clients outside of the area of practice) that may be unique to telemedicine (e.g., Oddo et al., 2021; Sibley et al., 2017). Reviewing national policies (e.g., the Health Information Technology for Economic and Clinical Health Act), books on the topic (e.g., Luxton et al., 2016), and partaking in continuing education courses are the critical starting places (e.g., American Psychological Association, 2021).

Second, practitioners need to consider client preference and individual circumstances in deciding whether to use telemedicine. Specifically, patient preference for delivery format appears to play an important role in satisfaction with telemedicine (Adamou et al., 2021; Wyler et al., 2021). As such, it is strongly advised that practitioners assess patient/family preference and feasibility of accessing care in person versus via telemedicine. This is especially true as we emerge from the COVID-19 pandemic, when engaging in F2F interactions/in-person sessions was highly politicized, perhaps resulting in differential preferences for intervention formats. There was mixed evidence regarding telemedicine format, with some clients who clearly preferred videoconferencing (Wyler et al., 2021) and others requesting to use the telephone only rather than videoconferencing (Reese et al., 2012), suggesting that preference may relate to treatment utilization and thus efficacy. Similarly, when both text messaging and telephone consultations were offered, utilization of telephone consultations was low (14.6%; Shah et al., 2021). In addition, it is critical that practitioners engaging in telemedicine services set clear expectations for patients regarding only engaging in treatment while in a secure and private location within the state the practitioner is licensed to practice in. Practitioners are advised to always query at the beginning of a session regarding the client's location; however, this can be difficult to ascertain. Recent advancements such as the Psychology Interjurisdictional Compact (PSYPACT; https://psypact.site-ym.com/) have made practicing across state lines more feasible; however, there are still important limitations that practitioners need to be aware of (e.g., that the practitioner needs to be physically located within the state they are licensed). In making decisions regarding the implementation of telemedicine, it is important for practitioners to consider which clients may or may not be appropriate for engaging in telemedicine services (Alvord et al., 2017). Although children with ADHD are often not directly involved in psychosocial or behavioral therapy outside of skills-based organization, time management, and planning interventions (Evans et al., 2018), even adolescents and adults with ADHD may be too prone to distractions that conducting therapy in an uncontrolled environment, such as the client's home, would not be advisable (Alvord et al., 2017). In addition to disorder-related factors (e.g., attentional capacity), going forward, practitioners also need to consider that some of their clients (e.g., those who previously drove a long distance or who had to acquire childcare to attend in-person sessions) may continue to prefer telemedicine sessions. As such, moving back to a fully in-person practice may reduce a practitioner's case load, relative to offering both in-person and telemedicine services.

Third, practitioners need to consider practical factors including billing through insurance, collecting and securely storing documents (e.g., consent forms), and circumstances around the provided intervention. Practitioners who try to navigate both in-person and telemedicine work may find there to be logistical challenges in collecting and securely storing documents for telemedicine patients. Specifically, practitioners will need to decide whether they want to email/mail blank forms to all clients, which they then can return via mail, or if they want to use a secure, HIPAA-compliant data management site for collecting electronic consent forms. For practitioners working from home, securing such forms and client notes also requires careful consideration to make sure that family members do not have access to patient identifying and personal information (e.g., keeping physical files in a locked filing cabinet, and using secure and encrypted online storage systems for electronic files). With regard to insurance companies, practitioners will be faced with challenges of different companies having different requirements for reimbursing telemedicine services. For example, some practitioners will only be reimbursed for telemedicine that is conducted while located outside of their home. As such, practitioners will likely still need to keep a physical office space regardless of the proportion of in person versus telemedicine services they are providing. Finally, many of the studies reviewed in this chapter involved relatively brief interactions with mental health providers (e.g., single sessions for prescribing ADHD medication, and two phone consultations while completing a self-paced intervention). It appears from the studies reviewed in this chapter that such brief interventions are better than no treatment; however, practitioners are cautioned to jump directly to these more limited, briefer interventions over existing, more in-depth, evidence-based practices until further research on the relative efficacy of such interventions is available. In particular, decisions around ongoing medication management for telepsychiatry visits will be important, given that several studies found that many patients only engaged in a single telepsychiatry session.

23.8 Conclusions

Telemedicine appears to be acceptable, feasible, and effective for the delivery of both pharmacological and psychosocial/behavioral interventions for ADHD, particularly for use with families of children and adolescents with ADHD. Not surprisingly, behavioral parent training as a standalone intervention or in combination with pharmacological interventions was the intervention with the largest number of telemedicine studies. In contrast, only two studies have explored the utility of telemedicine for the assessment of ADHD: one with children/adolescents and one with adults. As such, more research is needed in this area. Additionally, although there has been an increase in studies with adults with ADHD during the COVID-19 pandemic (from one to six studies), more research is still needed in this area, particularly for adults outside of the emerging adult developmental period. Finally, it will be critical for future research to explore individual and intervention factors that may related to treatment efficacy for telemedicine pharmacological and psychosocial/behavioral interventions.

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Cognitive Behavior Therapy for Adults with ADHD

24

Laura D. Eddy and Kaleb R. Martin

Cognitive behavior therapy (CBT) has been successfully applied to treat a variety of conditions. In the past two decades, this treatment has been adapted to the treatment of adults with attention-deficit/hyperactivity disorder (ADHD). Below, we provide an introduction to basic principles and key characteristics of CBT, discuss the rationale for using CBT to treat adults with ADHD, review and discuss research support for the use of CBT to treat ADHD in adults, and provide a discussion of key treatment components.

24.1 Cognitive Behavior Therapy: Theory, Research Support, and Application to ADHD

Early attempts to explain psychopathology emphasized the role of unconscious conflicts. With the rise of behaviorism, the understanding of factors contributing to psychopathology shifted toward explanations based on principles of learned behavior. As the field progressed further, the role of cognitions (i.e., thoughts) in shaping human experience was increasingly explored and acknowledged.

CBT recognizes the interplay between behaviors, cognitions, and emotions and provides a framework for understanding psychopathology. From this stance, distress and difficulties arise from problematic behaviors, unhelpful cognitions, and painful emotions. At its core, CBT maintains that psychological problems are attributable, at least in part, to both unhelpful thinking patterns *and* learned unhelpful behaviors; also, psychological problems can be treated by teaching individuals better coping strategies and skills, leading to symptom relief.

A person who is suffering from depression, for instance, may experience thoughts that "Nobody likes me" and "Why bother going to work today when I'll just mess up again?". These unhelpful thoughts may originate from their depressed mood, but they also serve to cyclically maintain the depression since the thoughts impact how they feel. Furthermore, because of their depressed mood, they struggle to go to work, thus missing opportunities to improve their mood by engaging with coworkers, completing assignments (feeling purposeful), and other naturally rewarding experiences. Thus, their avoidant behavior also serves to reinforce the depression through missed opportunities; instead, this person remains at home where they ruminate on unhelpful thoughts that further decrease their mood.

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The evidence base for CBT is quite strong – this treatment approach has demonstrated efficacy in treating a multitude of mental health disorders in many populations. In a review of 269 meta-analyses, Hofmann et al. (2012) found CBT to be the most effective treatment, or an equally effective treatment compared with others, in nearly 20 different mental health areas of concern. These included substance use, psychotic disorders, mood disorders, trauma, eating disorders, sleep disorders, anger, criminal behavior, general stress, distress due to medical conditions, chronic pain, and pregnancy complications, among others (Hofmann et al., 2012). Furthermore, given the strength of the evidence combined with the cost-effective nature of this treatment, these authors suggested CBT should be the standard first-line approach for mental disorder intervention in most countries (Hofmann et al., 2012).

CBT has several key characteristics – an emphasis on skill-building, a focus on present concerns, standardization in procedures, and active engagement in learning and practicing skills. Each of these is explained in more detail below. First, as noted above, CBT conceptualizes psychopathology as being driven by unhelpful patterns of behavior and unhelpful thinking patterns. Accordingly, a key focus of CBT is teaching skills to address and adjust these patterns. The particular skills included may vary according to the target problem. Some examples of target skills in CBT include relaxation, problem-solving, communication, and social skills (O'Donohue & Fisher, 2012). Second, many CBT approaches are manualized, including a standard number of sessions with particular content and focus. This standardization allows for consistency in the delivery of treatment. Third, CBT emphasizes current distress and concerns rather than focusing on events occurring far in the past. Finally, CBT views therapy as an active process in which practice and implementation of skills are important. For this reason, clients are often asked to complete practice activities outside of the session. Importantly, a collaborative relationship is a key backdrop for the work of CBT - the relationship between therapy providers and clients provides an important foundation for engaging in the therapeutic work of CBT.

24.1.1 Rationale: Why CBT for ADHD?

Before addressing the research support for the use of CBT to treat ADHD in adulthood, it is important to consider *why* CBT might be helpful in the treatment of this lifelong condition. First, as noted above, CBT puts an emphasis on understanding connections between cognitions/thoughts, emotions, and behaviors. In CBT, clients are provided with information, instruction in skills, and guided practice of skills in order to build the ability to cope with symptoms and improve functioning in many areas of life. CBT's focus on teaching skills to change behavior (which will be referred to as "behavioral skills" from here on) is an excellent fit for the difficulties and challenges experienced by adults with ADHD for several reasons.

24.1.2 Limits of Medication

First, it is important to acknowledge that there is ample research evidence to support the use of medication to treat ADHD in adults. Medications, particularly stimulant-class medications, are associated with significant reductions in core symptoms of ADHD and associated impairments (Wilens, 2003; Rostain, 2008). However, it is also true that many adults with ADHD taking medication continue to experience residual symptoms and ongoing difficulties. In fact, findings suggest that medication as a stand-alone treatment may be insufficient in up to 50% of cases (Wilens et al., 2001).

Furthermore, there are some limits to the use of medication. First, some individuals may not be able to tolerate medications due to intrusive side effects (e.g., loss of appetite and sleep disruption). Moreover, it is important to acknowledge that adults with ADHD may make the choice to forego medication as a treatment for ADHD for a variety of reasons. Some may find the side effects too severe. Others may be unable to afford the ongoing cost of a daily prescription combined with the costs of medication management, which requires regular visits to a prescriber. Individuals may also choose to forego medication as a treatment for ADHD entirely, based on personal preference. In all of these situations, psychosocial treatment in general and CBT in particular are important treatment options for managing the impact of ongoing ADHD symptoms.

Finally, in order to maximize the effectiveness of medication, one must adhere to a regular (daily) regimen and manage ongoing appointments with a prescribing provider. Although this sounds simple enough, these behaviors do require ongoing monitoring of one's own behavior, as well as organization and planning. Of course, these are the exact areas that are often more challenging for adults with ADHD, as some of the core symptoms of ADHD (such as forgetfulness and distractibility) often interfere with planning, organizing, and monitoring one's daily behavior. The skills and strategies that are often the focus of CBT for adults with ADHD can help address these barriers to consistent medication use, thereby maximizing its effectiveness. For instance, an individual could use visual reminders or prompts to cue themselves to take their medication each day after eating breakfast, thus ensuring that they have eaten a solid meal before taking medication. We discuss many more examples and possibilities of such strategies in Sect. 24.2.2.

24.1.3 Cognitions

Another key reason for using CBT to treat ADHD is the focus on addressing unhelpful thinking patterns with cognitive techniques. This is important for multiple reasons. First, the core symptoms of ADHD and associated difficulties have often led to experiences of failure or problems with achieving personal goals. For example, academic performance can be impacted by difficulties with sustaining focus, thus limiting educational attainment despite intellectual abilities. This is supported by findings that adults with ADHD attain less education than their intellectual abilities would suggest (Biederman et al., 2008). Over time, these experiences can contribute to a pattern of self-doubt that is apparent in thoughts such as "I never do well in school" or "I always screw things up." In turn, these thinking patterns increase vulnerability to anxiety and depression (Eddy et al., 2018). Cognitive techniques (discussed in more detail in the section titled "Cognitive Strategies") commonly taught in CBT are designed to help reduce and adjust these types of negative thinking patterns. Accordingly, cognitive strategies as a key component of CBT may play an important role in both reducing ongoing symptoms of comorbid depression and anxiety and preventing the development of comorbid depression and anxiety disorders.

Importantly, addressing comorbid depression and anxiety is not the sole reason for including cognitive strategies in the treatment of ADHD in adults. Historically, cognitive techniques have received less focus in the context of treatment of ADHD in adulthood in comparison to behavioral techniques (for an excellent detailed discussion of this topic, see Ramsay (2017)). In general, the prevailing sentiment has held that managing symptoms of ADHD through the use of medications and behavioral coping techniques is the primary focus of treatment, and the implementation of cognitive strategies has been perceived as a secondary element, important only insofar as it addresses comorbid symptoms of depression and anxiety. In contrast to this view, there is increasing evidence supporting the fact that although unhelpful thinking patterns do not *cause* ADHD, they are certainly associated with ADHD. For example, in comparison to adults without ADHD, adults with ADHD demonstrate higher levels of unhelpful thinking patterns, even in the absence of cooccurring depression (Abramovitch & Schweiger, 2009; Mitchell et al., 2013). Furthermore, particular types of procrastination may be driven by unhelpful thinking patterns. For instance, the thought "I do my best work at the last minute" or variations of this belief have been noted by multiple authors addressing the topic of unhelpful thinking patterns associated with ADHD (Knouse & Mitchell, 2015; Ramsay, 2017). This type of thought tends to lead to procrastination, which is a common problem for adults with ADHD.

For all of these reasons, cognitive techniques should be viewed as a key component to CBT for adults with ADHD.

24.1.4 Chronic Nature of ADHD

Finally, ADHD is a chronic condition for a majority of individuals (Biederman et al., 2010), and the symptoms of ADHD can interfere with a variety of areas of life. Building the ability to effectively manage ongoing symptoms is a lifelong process for most individuals with ADHD. Skills and strategies can (and should be) applied and used even after treatment has ended. While this is certainly helpful for people struggling with a variety of mental health challenges, it is especially important for those with a chronic condition such as ADHD.

24.1.5 Psychoeducation

A common component of many of the CBT protocols and approaches designed for the treatment of ADHD in adulthood is an emphasis on psychoeducation. This refers to providing accurate information on the core symptoms, associated difficulties, and treatment options. While the exact content may vary slightly from one treatment protocol to another, the common goal is to increase individual's knowledge and understanding of ADHD in order to best equip them to take an active role in their own treatment. This is particularly important, given that people are exposed to inaccurate and misleading information in the course of daily life. Moreover, CBT offers the chance to provide information tailored to the individual's age and presentation. Many people diagnosed with ADHD are first diagnosed in childhood. As they grow into adulthood, they need updated information on how their ADHD symptoms may present differently later in life. They should also be provided with information on how symptoms can lead to different types of risks that only become relevant later in life. One excellent example is learning to drive a car. ADHD is associated with greater driving-related problems. For instance, young adults with ADHD are at a higher risk of automobile accidents and speeding citations. While this information is not currently relevant for a six-year-old diagnosed with ADHD, it will become highly relevant later in life. Accordingly, to help people best manage their symptoms, they should be provided with psychoeducation tailored to their particular stage in life. CBT puts a focus on psychoeducation that facilitates a better understanding of this lifelong condition.

24.1.6 Research Evidence

While the use of CBT in the treatment of conditions such as depression and anxiety is long-standing, the use of cognitive behavioral therapy to treat ADHD in adulthood is a relatively recent development. In recent years, the use of CBT for ADHD in adults has become far more widespread, and it is fair to state that in the realm of psychosocial treatment for ADHD in adults, CBT is considered the first line of treatment based on the research evidence for its efficacy (Knouse et al., 2017; Ramsay, 2010).

In a recent meta-analysis assessing the evidence for the use of CBT to treat ADHD in adulthood, findings suggested that CBT resulted in significant improvements in terms of ADHD symptoms and general functioning with effect sizes ranging from medium to large across outcomes (Knouse et al., 2017). Importantly, the effects of treatment did not vary according to medication status or treatment format. This indicates two things: CBT does not need to be combined with medication treatment in order to be effective and both group and individual treatment approaches are viable formats. Below, we discuss the existing research on CBT for the treatment of ADHD in adulthood in more detail and highlight key components of these treatment approaches in order to help identify important commonalities. Importantly, for the purposes of this review, we have included studies testing treatment protocols that are either described by the authors as cognitive behavioral treatments or those that are clearly consistent with cognitive behavioral treatment. In addition, we review the treatments designed to be primarily delivered by trained therapists, as opposed to primarily self-directed interventions (e.g., Stevenson et al., 2003; Moëll et al., 2015) or ADHD coaching interventions (e.g., Prevatt & Yelland, 2015). Finally, we have included treatments designed to treat ADHD as the primary area of focus; therefore, approaches designed to treat comorbid symptoms in the context of ADHD (e.g., Bramham et al., 2009) are not discussed. While the results from these studies are certainly promising, they are outside the scope of this chapter. Additionally, it should be noted that dialectical behavioral therapy and mindfulness-based cognitive behavioral therapy, which are considered "third-wave" cognitive behavioral treatments, have been applied to treat ADHD in adults with promising results; however, these topics are addressed in other chapters in this volume. Accordingly, we do not review the research for these treatment approaches here.

24.1.6.1 Individual Therapy

The earliest trial of cognitive behavioral treatment for adults with ADHD delivered in an individual format was conducted by Rostain and Ramsay (2006). In this study, potential participants were first comprehensively assessed and diagnosed with ADHD, then treated with a combination of CBT and pharmacotherapy/medication. This treatment approach was later published as *Cognitive Behavioral Therapy for Adult ADHD: An Integrative Psychosocial and Medical Approach*. Outcomes included ADHD symptoms, ratings of ADHD severity, overall functioning, and depression and anxiety symptoms. Results were highly promising – participants who completed treatment ($N = 43$) demonstrated significant improvements in all outcomes. This suggested that this combined treatment approach held the potential for the treatment of ADHD in adults. However, given the combined nature of this treatment approach, it was not possible to disentangle the effects of CBT from the effects of medication. It is interesting to note that the original intent and design of this study was to compare outcomes of adults treated with a combination of CBT and medication, those treated with CBT only and those treated with medication only. However, the vast majority of participants selected combined treatment (CBT plus medication) as their treatment of choice as opposed to medication only or CBT only. Accordingly, the number of participants in these groups was too small to conduct a comparison of treatment effects. This certainly indicates a general interest and openness in this treatment approach.

Safren and colleagues developed and tested a cognitive behavioral treatment protocol for ADHD in adults consisting of 12 individual therapy sessions, which was later published as *Mastering Your Adult ADHD: A Cognitive-Behavioral Treatment Program*. The treatment protocol included psychoeducational information about ADHD, instruction in behavioral strategies designed to facilitate planning, organization, and manage distractibility, and cognitive strategies designed to promote adaptive thinking and reduce thinking patterns associated with distress and problems. Participants were instructed to engage in practice and implementation of skills outside of session. In an initial study of this treatment, 31 adults with ADHD already receiving medication treatment (mean age = 45.5) were randomized to receive either this cognitive behavioral treatment or ongoing medication management (Safren et al., 2005). Results indicated that the group receiving CBT demonstrated significantly lower ADHD symptoms and lower general illness severity (i.e., general functioning as rated by study clinicians) at the conclusion of treatment compared to the control participants. Furthermore, participants in the CBT group reported lower levels of depression and anxiety at the conclusion of treatment. Importantly, these results were observed on self-report measures as well as ratings conducted by independent observers (Safren et al., 2005). Additional evidence for the efficacy of this protocol was provided by a randomized controlled trial testing this treatment against an active treatment control condition with a sample of 86 adults (mean age = 42.3; Safren et al., 2010). All participants in the study were receiving active and ongoing medication management to treat ADHD and had been identified as patients who might benefit from additional treatment. Participants in the active treatment control condition received relaxation training and educational support. Significantly, more participants in the CBT group responded to treatment, showing improvements across self-rated ADHD symptoms as well as observer-rated ADHD symptoms and general illness severity. For those who responded to CBT, improvements were maintained at 6 months and 1 year posttreatment (Safren et al., 2010).

Weiss and colleagues tested the efficacy of a cognitive behavioral treatment for adults with ADHD, which included a particular focus on problem-solving in a randomized controlled trial conducted across five sites (Weiss et al., 2012). The treatment protocol (nine sessions) included a focus on psychoeducation about ADHD as well as instruction in problem-solving approaches. Importantly, this treatment also included a focus on teaching and implementing strategies such as organizational techniques and prioritizing techniques in order to address key difficulties identified by participants. Finally, participants were instructed to engage in active practice of skills outside of sessions. Treatment occurred every 2 weeks for the first seven sessions, with the final two sessions occurring once monthly. Participants ($N = 48$) were randomized to receive either CBT plus medication (dextroamphetamine) or CBT with a placebo. Further, both participants and therapists administering CBT were blind to treatment condition (i.e., whether participants were receiving medication or a placebo). Thus, this study provided a rigorous direct comparison of the efficacy of this treatment with and without concurrent medication. Further, the fact that both patients and therapists were blind to treatment condition provided a way to control for the impact of both therapist and patient expectations on treatment outcome. Results indicated robust effects of both treatments on both ADHD symptoms and general functioning (effect sizes ranging from moderate to large). There was no significant difference in outcomes across groups, although there was a trend for the group receiving CBT plus medication to show greater improvement. Furthermore, improvements were maintained as treatment was tapered from biweekly sessions to monthly sessions, which occurred at 15 and 20 weeks after the start of treatment (Weiss et al., 2012).

Van der Oord et al. (2020) tested the effectiveness of a brief (six sessions) cognitive behavioral treatment for college students with ADHD in a controlled trial. This intervention was designed for implementation in college counseling centers. It included a focus on planning and organizational skills, particularly as applied to studying and managing academic works. The treatment also included psychoeducation about ADHD and a focus on goal setting and planning to implement skills. Participants ($N = 58$) were assessed to confirm their diagnosis of ADHD, then randomized to the intervention condition or a waitlist control condition. Importantly, some participants were receiving medication to treat ADHD and others were not – approximately 83% of the overall sample reported taking medication to treat ADHD. The percentage of participants in the waitlist control group taking medication was higher (93%) as compared to the treatment group (73%). Participants were asked to refrain from making changes to their medication treatment during the course of the study. Treatment was provided by licensed therapists working in college counseling center settings who were given an eight-hour training prior to the start of treatment. Thus, these conditions closely mimic the real-world implementation of treatment protocols. At posttreatment, participants in the cognitive behavioral intervention group demonstrated significantly greater improvements in symptoms of inattention but not in measures of study skills or comorbid symptoms (e.g., depression, anxiety; Van der Oord et al., 2020).

Taken together, results from these studies indicate that CBT delivered in individual sessions is associated with improvements in terms of both ADHD symptoms and general functioning. All of the treatment protocols used in the studies described above were short-term (ranging from 6 to 12 sessions), structured, and included an emphasis on psychoeducation, skill building, and practice/implementation of skills. Furthermore, findings suggest that CBT can result in improvements for adults with ADHD who are *not* receiving concurrent medication for ADHD (Weiss et al., 2012) and for those who are stabilized on a medication regimen but report continued difficulties and impairments (Safren et al., 2005, 2010). Finally, there is evidence that CBT can be effective when implemented outside of highly structured and controlled research studies (Van der Oord et al., 2020).

24.1.6.2 Group Therapy

Solanto and colleagues developed metacognitive therapy, a group cognitive behavioral intervention. The treatment protocol included 12 sessions (2 hours apiece) delivered weekly for 12 weeks. The focus of this treatment included building organization, time management, and planning skills, in addition to recognizing and challenging unhelpful thinking patterns. As with other cognitive behavioral interventions, this treatment included a focus on participants implementing and practicing skills outside of session. Further, the authors note that the group design allowed the modeling of skills by other group members, as well as positive reinforcement from other group members and the therapist. In a randomized controlled trial testing the efficacy of this treatment, 88 adults diagnosed with ADHD were assigned to one of two active treatment conditions: metacognitive therapy or supportive therapy. Supportive therapy consisted of sessions in which general therapeutic skills were utilized but not cognitive behavioral techniques. Participants in the metacognitive therapy group improved significantly more on measures of ADHD symptoms; moreover, a great number of participants in the metacognitive group were categorized as treatment responders. Impressively, improvements were demonstrated both on self-report measures completed by participants themselves, as well as on measures completed by independent observers and by collateral reporters (e.g., participants' partners, roommates, and friends, who were asked to rate symptoms). Many participants were on a concurrent medication regimen to treat ADHD; however, they were required to be on a stable regimen at least 2 months before starting treatment. Further, changes in medication were tracked and controlled for, and statistical analyses indicated medication status did not impact the results.

Another group CBT approach was tested by Virta and colleagues in an open trial followed by a randomized controlled study (Virta et al., 2010). Results from the initial open trial suggested that this group treatment approach resulted in significant improvements in self-reported ADHD symptoms at posttreatment. On the basis of these findings, a randomized controlled trial was conducted to further assess the efficacy of this approach. In this study, participants ($N = 29$) were randomly assigned to a group CBT treatment ($N = 10$), an individual cognitive training (CT) condition delivered virtually ($N = 9$), or a control condition receiving no treatment ($N = 10$). About half the sample was concurrently receiving medication to treat ADHD (58%). Participants were required to have a medication regimen that was stabilized at least 2 months prior to the start of treatment. The number of participants using concurrent ADHD medication was equivalent in each condition, that is, the rate of medication use was not significantly different across treatment conditions. The group CBT treatment included 10 sessions delivered weekly. Treatment included psychoeducation about ADHD, behavioral skills and strategies, and an emphasis on recognizing and adjusting unhelpful thinking patterns. Participants were given between-session practice assignments, and a review of these assignments was conducted in each session. The CT condition received a total of 20-hour-long sessions in which participants were asked to complete a number of computerized tasks designed to target a variety of cognitive abilities, including attention, executive functioning, and working memory. They received individual feedback on their performance from a psychologist. The sample size used in this study was small, which limited the ability to compare scores across groups with typical statistical analyses. However, the authors were able to categorize participants as treatment responders or nonresponders based on whether or not participants reported improvements in measures of ADHD symptoms. To be classified as "improved," participants had to demonstrate reductions in ADHD symptoms on three different self-report measures of ADHD symptoms. At the conclusion of treatment, it was clear that a larger proportion of CBT group participants improved using this definition. Specifically, 6 participants were classified as "improved" in the CBT group compared to 2 in the cognitive therapy group and 2 in the control group. In addition, a larger proportion of CBT group members (7 out of 10) were rated as "improved" on measures of general functioning completed by independent evaluators who were blind to treatment condition. In comparison, only 2 participants in the CT group and 3 participants in the control group were rated as improved. Furthermore, a follow-up study demonstrated that those participants who improved in the original Virta et al. study maintained their improvement at 3 and 6 months after treatment (Salakari et al., 2010). Thus, the positive effects of treatment appeared to be persistent. In sum, results suggested that CBT delivered in a group format tended to result in lasting improvement; however, the small sample size severely limits the conclusions that can be drawn from this study.

Another group-based CBT treatment was tested in a randomized controlled trial conducted in China ($N = 108$; Huang et al., 2019). This study tested the implementation of the Safren and colleagues' protocol (Safren et al., 2017) in a group format. Participants were randomized to a waitlist control ($N = 22$), a 12-session CBT group ($n = 43$), or a 12-session CBT group plus three booster sessions ($N = 43$). Groups occurred weekly for 12 weeks, with sessions lasting 2 hours. Groups were composed of eight to twelve participants. After 12 weeks, booster sessions were conducted once per month (3 sessions) and treatment concluded after 24 weeks. Of note, the percentage of participants receiving concurrent medication to treat ADHD was fairly low (38.89%). Results indicated that after 12 weeks, both the CBT and CBT plus booster conditions demonstrated significant improvements in ADHD symptoms and executive functioning difficulties compared to the waitlist control condition. However, significant differences on measures of quality of life, depression, and anxiety were not observed. When groups were compared at 24 weeks (after booster sessions), there was no significant difference between those receiving CBT and those receiving CBT plus booster sessions.

Philipsen and colleagues conducted a large ($N = 419$) randomized controlled trial testing the efficacy of group cognitive behavioral therapy for ADHD against the effects of clinical management, which consisted of weekly individual sessions of supportive, nondirective counseling (15–20 minutes) designed to simulate general practice (Philipsen et al., 2015). Both the CBT group and clinical management sessions occurred weekly for 12 weeks, and then each was tapered to monthly sessions for an additional ten sessions. Furthermore, participants in each condition were separated into groups receiving either concurrent medication to treat ADHD (methylphenidate) or a placebo. Thus, this study was designed to assess the effects of group CBT both with and without medication; moreover, these effects were compared to the effects of clinical management both with and without medication. There was a significant treatment effect associated with methylphenidate - that is, participants who received either medication plus group CBT or medication plus clinical management showed a better treatment response on average than those receiving either treatment plus placebo. However, group CBT did not perform significantly better than clinical management – participants in both groups improved on measures of ADHD symptoms, but this improvement was not significantly stronger in either therapeutic condition (CBT vs. clinical management). It is important to note that group CBT did outperform clinical management on one particular measure - CBT was consistently associated with better ratings on the global assessment of effectiveness scale of the Clinical Global Impression scale (CGI), which indicates changes on constructs such as improved self-esteem and coping skills (Philipsen et al., 2015).

Finally, LaCount and colleagues tested a brief, three-session intervention for college students with elevated levels of ADHD symptoms and academic difficulties (LaCount et al., 2018). Participants ($N = 37$) were randomized to receive either the group treatment ($N = 22$) or a control (no treatment) condition ($N = 15$). This treatment, adapted from the metacognitive therapy protocol published by Solanto et al., placed a specific focus on organization, time management, and planning skills. Each group session was 1 hour long and focused on instruction in a particular skill. Consistent with other cognitive behavioral treatments, participants were encouraged to apply skills outside of session. At the end of treatment, participants in the group condition reported significantly lower levels of ADHD symptoms and academic problems compared to control group participants. However, although intervention group participants did show gains relative to control participants in organization, time management, and planning skills, these improvements were not large enough to represent reliable change. Further, these findings must be interpreted with caution, given that not all participants in the sample were diagnosed with ADHD (approximately 25% of the sample reported a prior diagnosis of ADHD). Nevertheless, it is certainly notable that improvements were observed after such a brief intervention.

As a whole, these findings suggest CBT delivered in a group format is associated with improvements in core ADHD symptoms. However, it is less clear to what degree this improvement might be attributable to the combination of CBT and medication. For instance, findings reported by Philipsen et al. (2015) suggest a main effect of medication, given that outcomes did not differ according to whether participants received group CBT or individual clinical management. In contrast, medication use did not impact the results reported by Solanto et al. Further, results from the Huang et al. (2019) study suggest improvements associated with CBT, despite the fact that a notably low percentage of participants (38.89%) were receiving concurrent medication treatment for ADHD. Thus, there is reason to suppose that group CBT can be effective regardless of medication status. Finally, there is preliminary evidence that improvements can be observed after even very brief (e.g., three sessions) interventions (LaCount et al., 2018).

24.1.6.3 Combined Approaches

A number of studies have evaluated cognitive behavioral approaches that combine group treatment with varying levels of individual treatment, mentoring, or contact. Often, this combination is designed to allow for the delivery of material and instruction in skills in the group component of treatment, while individual sessions focus on discussion of how to individually apply and tailor skills and strategies.

In the earliest test of this type of combined approach, Stevenson et al. (2002) tested an intervention described as “cognitive remediation,” which included key cognitive behavioral elements such as building skills to improve organization, focus, and task management as well as instruction in recognizing and challenging unhelpful thinking patterns. The treatment included eight sessions (2 hours long each) delivered weekly. Participants were also assigned “support persons” who functioned as coaches and facilitated implementation of skills and strategies taught in groups. In a randomized trial, participants were assigned to either the CBT intervention or a waitlist control condition. At post-treatment, participants in the CBT group demonstrated significant reductions in ADHD symptoms, improvements in organizational skills, and reduced anger. Effect sizes were moderate to large (Cohen’s d ranging from $d = 0.5$ to $d = 1.4$). Furthermore, treatment gains on measures of ADHD symptoms and organizational skills were maintained when assessed one-year post-treatment (Stevenson et al., 2002).

Young and colleagues tested a 15-session cognitive behavioral treatment including both group and individual components in a randomized controlled trial. Participants included 95 adults with ADHD, who were already receiving medication to treat ADHD. Participants were randomly assigned to receive either CBT or treatment as usual. Participants in the CBT group showed significantly greater improvements in ADHD symptoms at the conclusion of treatment, according to both participants' self-report and ratings completed by independent observers. Further, participants did show improvements on quality of life, depression, and anxiety; however, these effects were not specific to the CBT condition.

Another cognitive behavioral approach combining group and individual components was assessed by Emilsson and colleagues. This treatment consists of 15 sessions, conducted twice weekly. Groups were supplemented by individual coaching sessions (30 minutes) conducted in between group sessions. In a randomized controlled trial, participants ($N = 54$) who were already receiving medication to treat ADHD were randomized to receive either this cognitive behavioral group treatment or treatment as usual (i.e., ongoing medication management). Those receiving CBT demonstrated significantly greater improvements on measures of ADHD symptoms at post-treatment. This held true for both self-report measures of ADHD symptoms as well as ADHD symptoms rated by independent evaluators. Interestingly, additional improvements were observed at a three-month follow-up assessment. Specifically, the CBT group demonstrated significant improvement compared to the treatment-as-usual group on measures of depression and anxiety. Improvements in core ADHD symptoms were also maintained.

Some combined treatment approaches were developed specifically for college students with ADHD. Anastopoulos and colleagues developed a combined cognitive behavioral treatment designed for college students with ADHD, later published as *CBT for College Students with ADHD: A Clinical Guide to ACCESS* (Anastopoulos et al., 2020a, b). This treatment includes two phases, conducted over the course of two academic semesters. In the first phase, participants attend eight group meetings and eight to ten individual mentoring meetings. In the second phase of treatment, participants attend one group meeting and complete four to six individual mentoring meetings. This treatment approach was systematically developed via a pilot study followed by an open trial (Anastopoulos & King, 2015; Anastopoulos et al., 2020a, b). Evidence indicated this treatment resulted in improvements in ADHD symptoms, executive functioning, depression, and anxiety (Anastopoulos & King, 2015; Anastopoulos et al., 2020a, b); furthermore, these improvements were maintained 5–7 months after the start of treatment (Anastopoulos et al., 2020a, b). It was further evaluated via a large, multisite, randomized controlled trial (Anastopoulos et al., 2021). In the randomized controlled trial, 250 participants were randomized to receive treatment immediately or 1 year later (waitlist treatment control condition). Results from this trial indicated this treatment was associated with significant reductions in ADHD symptoms, reductions in executive functioning difficulties (Anastopoulos et al., 2021) as well as significant improvements on functional outcomes. Importantly, significant improvements were demonstrated on key areas commonly targeted in CBT, including the use of behavioral strategies to manage ADHD symptoms, improvement in knowledge of ADHD, and reduction in unhelpful thinking patterns (Anastopoulos et al., 2021). This suggests that this CBT intervention improves hypothesized active mechanisms of treatment.

Another combined cognitive behavioral treatment protocol targeting ADHD in college students was developed by Hartung et al. (2020). This intervention combines six group sessions with two individual sessions. It puts a particular emphasis on organization, time management, and planning skills and specific instruction in applying these skills in academic work. Like other CBT protocols, this treatment also includes psychoeducation about the core characteristics of ADHD. This intervention was first developed and pilot-tested in an open trial with 12 participants (LaCount et al., 2015). In this study, a combined group and individual format was used, including 10 group sessions and

10 individual sessions. Results suggested that this treatment was promising, with improvements in core ADHD symptoms and general functioning in multiple domains of life (LaCount et al., 2015). In an open trial, this treatment was associated with significant improvements from pre- to posttreatment in ADHD symptoms, impairment, self-concept, and use of organization, time management, and planning skills (Hartung et al., 2020).

Consistent with findings discussed in the individual and group therapy sections, there is reason to conclude that cognitive behavioral treatment utilizing a combined approach (i.e., group plus individual treatment elements) is effective in the treatment of ADHD in adulthood. It is notable that two of the studies discussed above tested the efficacy of CBT for adults already receiving medication to treat ADHD. Other studies testing a combined approach included samples in which some, but not all, participants were receiving concurrent medication to treat ADHD (Anastopoulos et al., 2021; Hartung et al., 2020). Importantly, these studies reported significant improvements in a number of outcomes (ADHD symptoms, functional impairment), suggesting that CBT delivered in a group approach can be effective either when delivered without concurrent medication or in combination with medication to treat ADHD. However, it should be noted that these studies either did not include a control group (Hartung et al., 2020) or utilized a waitlist control (Anastopoulos et al., 2021). In addition, both studies were designed to evaluate the efficacy of CBT for young adults with ADHD attending college, in particular (Anastopoulos et al., 2021; Hartung et al., 2020). In sum, there is enough evidence to conclude that CBT delivered in a combined format is effective for treating ADHD in adults receiving concurrent medication to treat ADHD. There is some evidence to support the conclusion that CBT delivered in a combined format is effective for college students with ADHD, regardless of medication status. Additional research including studies testing the effects of combined protocols with and without concurrent medication would be helpful in distinguishing between the effects of CBT alone and the effects of medication plus CBT.

24.2 CBT for Adults with ADHD: Key Treatment Components

In the previous section, we reviewed the existing research on the use of CBT to treat ADHD in adulthood. Below, we highlight key techniques and strategies that are common to many of the manualized treatments described above. We have organized this section into three major areas: Psychoeducation, Behavioral Strategies, and Cognitive Strategies. This section is not meant to serve as a treatment manual; instead, the goal is to provide an introduction to some of the most commonly used techniques in CBT for ADHD in adulthood.

24.2.1 Psychoeducation

The vast majority of cognitive behavioral treatment protocols for adults with ADHD begin with some level of psychoeducation on the topic of ADHD. This generally includes a discussion of the core symptoms of ADHD, with a focus on explaining how the clinical terms reflecting criteria for ADHD (e.g., "trouble sustaining focus) translate into the behaviors, tendencies, and challenges occurring in the lives of adults with ADHD. Depending on the treatment approach, this portion of treatment might also include a discussion of the neurobiological basis of ADHD, and presentation of information about key areas of difficulty for adults with ADHD. The goal of providing such information is to increase understanding and awareness. This is often provided at the start of treatment, since greater understanding and awareness may translate to a stronger belief in the potential of improvement with treatment (i.e., positive outcome expectations). Robust research findings support associations between clients' outcome expectations early in treatment and posttreatment outcomes (Constantino et al., 2018). Accordingly, strengthening client beliefs in the potential of improvement with treatment is no small goal, but rather a key pathway through which to positively influence outcomes.

In addition to building accurate knowledge and understanding of ADHD, psychoeducation can also have the overlapping effect of correcting myths and misunderstandings about ADHD. This is no small goal, given the proliferation of inaccurate information about ADHD that is available online. For example, despite the fact that there is no systematic research evidence supporting the use of cannabis to treat ADHD, in an interesting qualitative analysis of posts in online discussion forums, Mitchel and colleagues found that 25% of posts endorsed beliefs that cannabis was useful as a treatment for ADHD. In contrast, only 2% of posts expressed the view that cannabis was neither harmful nor helpful (Mitchell et al., 2016). This serves to highlight the fact that people are exposed to a variety of information relating to ADHD online, and not all of this information will be anchored by accurate sources.

24.2.2 Behavioral Strategies

Most, if not all of the treatment protocols used in the research reviewed above includes a focus on techniques that we will refer to as "behavioral strategies." The theoretical premise of these strategies draws from learning principles commonly used in behavioral therapy. For instance, positive reinforcement, negative reinforcement, and modeling are all key principles that underlie the rationale for many of the following techniques and strategies. These principles are applied in order to understand the reasons for problematic patterns of behavior and also guide the application of intervention techniques to modify problem behavior. For example, adults with ADHD often report difficulty with distractibility – that is, when working on a task they may find their attention wanders to other things – they may look out the window, or check their phone, or get drawn into a conversation with a coworker. This tendency can be understood as having a tendency to be drawn to more *immediate* positive reinforcement (engaging conversation, phones, an interesting view from the window) at the expense of the (more delayed) reinforcement that follows completion of a task. Understanding this tendency in behavioral terms allows for the application of a number of strategies to alter the problem behavior. For instance, one might make changes in the environment and reduce distracting stimuli by sitting away from the window, putting one's phone away and silencing it while working, or putting in headphones or closing one's office door to forestall conversations.

Moreover, one of the consistent themes observed across treatment manuals and protocols is a focus on strategies that promote effective organization, time management, and planning. Many of the key problems associated with ADHD are linked to problems with completing tasks and attaining goals. This can occur in a workplace, in a school environment, at home, or when setting personal goals (e.g., getting adequate sleep and eating a healthy diet). To complete goals, we must engage in planning, organizing, monitoring, and adjusting our own behaviors. The core symptoms of ADHD often interfere with the ability to do so. For instance, difficulties with organization can lead to problems with planning when to complete a task, and difficulties sustaining focus can lead to problems with completing a task in the time required. Although the use of these strategies is not restricted to the realm of CBT, it is certainly highly relevant for adults with ADHD, who commonly struggle with planning, organizing, and monitoring their own behavior in order to meet goals.

In sum, there are numerous strategies and skills within the category of behavioral strategies. Below, we seek to highlight many commonly used strategies, illustrate how these are applied, and discuss the general rationale for each. This is certainly not a comprehensive list of each and every behavioral strategy that can be utilized in CBT for adults with ADHD; rather, this is designed to provide readers with an introduction and a general feel for the topic. Importantly, there is often not one "correct" way to execute each skill. Instead, strategies can be personalized to meet an individual's needs while utilizing their strengths. Implementation may look somewhat different across individuals.

24.2.2.1 Calendars and Planners

A common recommendation in CBT for adults with ADHD is to implement the use of a calendar/planner. In short, this involves the use of a system to keep track of appointments and deadlines and to facilitate general planning. The format used might be digital, paper, or a combination of both. These tools provide a central place to enter deadlines, doctor's appointments, regular meetings, and so forth. This minimizes the chance of overlooking or forgetting deadlines and appointments and allows for more effective planning of time.

24.2.2.2 Task Lists

Another frequent recommendation is implementing a task list system, which provides a central location for adults with ADHD to keep track of ongoing tasks, projects, and responsibilities. Having a central location in which to record tasks allows better management of the variety of tasks and responsibilities that an individual may have. Further, regular review of a list helps reduce the tendency to procrastinate, which is a commonly reported concern among adults with ADHD.

24.2.2.3 Breaking Down Tasks

A related strategy is breaking large tasks into smaller parts. In our experience, adults with ADHD often report feeling "overwhelmed" by tasks. This can occur when facing large, complex tasks or when managing multiple tasks at once. In response to this distress, it is common to procrastinate. Procrastination serves as a means to "escape" the distress and is therefore operating according to the principle of negative reinforcement. Since procrastination removes something aversive (distress) it is more likely to continue to occur, despite the fact that it often leads to even more problems and difficulties later. For example, putting off an intimidating project can result in feeling better momentarily, but can lead to rushing to finish work at the last minute, turning in half-completed work, or missing deadlines. To counteract the possibility of procrastination, it is helpful to break a task into smaller parts which often feel more manageable. This is often referred to as subtasking, or "chunking" tasks into smaller steps. Further, this allows for more immediate reinforcement of on-task behavior. An adult with ADHD using this strategy can integrate some sort of positive reinforcement after completing each subtask. For instance, they might get a coffee after completing the first subtask and take a brief break after completing the second subtask, and so on. Thus, they are positively reinforcing their own on-task behavior.

24.2.2.4 Focusing and Managing Distractibility

Once a task is identified and broken into steps if necessary, it is still important to sustain attention while working on the task. This can be challenging since the trouble with sustaining attention is a common symptom of ADHD. Further, sustaining attention inherently requires the management of distractibility, another key symptom of ADHD. There are a number of different behavioral strategies that can be applied to help sustain attention. Two common recommendations are setting specific, relatively brief, time-based goals and keeping a notepad or other place to write down and track distracting thoughts.

In contrast to setting a goal of completing one task (i.e., completing a report at work), using time-based goals involves working on one particular task for a certain length of time (e.g., 10 or 25 minutes). The use of a timer is encouraged to track this. At the end of this period, one can take a brief break (e.g., 5 minutes). Different approaches have been used to define the ideal time – some prefer to set a specific length of time such as 25 minutes. It is also possible to tailor the length of time to a particular person's attention span.

To help manage distraction during these focus periods, it can be helpful to keep a place to quickly jot down or note distracting thoughts. Then, these can be reviewed later. This prevents jumping to another task before the first has been completed. For example, when working on a large project, someone may suddenly remember a need to pay their monthly phone bill. Instead of stopping what they are currently doing, they can write it down and use the upcoming 5-minute break to complete this task. Further, there are now numerous applications that block specific browser URLs or phone apps for select time periods as well as "focus modes" on computers and phones. All these tools aid in preventing distractions during task execution.

24.2.2.5 Prioritization Techniques

Adults with ADHD may engage in what has become known as "productive procrastination." In other words, an adult with ADHD may avoid a pressing, important task by working on several other tasks from their task list which are not as important. This represents a breakdown in the ability to prioritize tasks effectively. Accordingly, learning to effectively prioritize tasks is a frequently used strategy in CBT for adults with ADHD. Different prioritization systems have been suggested – the common theme is systematically deciding upon the level of importance for some particular task (e.g., A = must complete today, B = can be put off until tomorrow, and C = can be put off for a few days). This categorization of tasks then guides the order of completion (using the example given above, all "A" tasks are completed first, followed by B tasks and C tasks).

Many of the strategies described above help manage the impact of symptoms in situations where individuals have some control over their activities. However, there are many situations in which people may be required to sit and focus for a sustained period of time (e.g., during a work meeting or in class). In such cases, behavioral cues can be used to build associations and bring awareness to this unconscious process of becoming distracted.

24.2.2.6 Cues, Prompts, and Reminders

In order to change problem behaviors and build more effective behaviors, one can construct and implement various types of cues that prompt certain behaviors. This is consistent with behavioral principles. Specifically, cues serve as "stimuli" that prompt a learned behavior. For example, to address forgetfulness (a common complaint among adults with ADHD) the use of visual cues can be helpful. Visual cues can take the form of colored notes, drawings, objects, and so forth. To promote consistent medication use, placing a medication bottle on top of a bathroom sink in clear view can prompt the behavior of taking a medication. Similarly, post-it notes or reminders linked to smartphones can prompt a variety of adaptive behaviors. Instead of relying on one's ability to remember to complete the behavior, we alter the environment (build a visual cue) and therefore increase the likelihood the behavior will actually occur.

It is also possible to use actions or events as "cues" to engage in certain behaviors. This can be particularly helpful in trying to alter or reduce problem behavior. For example, an adult with ADHD may report frequently becoming distracted in office meetings. They report having trouble catching this behavior before it occurs – instead, they often become aware they have lost track of the meeting after having missed importation material. This adult typically has a cup of coffee or water in these meetings. To help reduce their distractibility, they use their awareness of becoming distracted as a "cue" to reach for the cup, take a sip, and refocus their attention on the meeting. Therefore, the recognition of losing focus cues a specific behavior (reach for cup, take a sip) and prompts them to refocus their attention.

24.2.3 Cognitive Strategies

In addition to the behavioral strategies described in detail above, CBT typically includes a focus on identifying, challenging, and adjusting unhelpful thinking patterns. This is particularly useful and relevant for adults with ADHD for a number of reasons. In many cases, unhelpful thinking patterns have developed, which lead to sadness and frustration. As documented in other chapters of this volume, adults with ADHD experience impairment in a number of life domains. Often, this impairment stretches back to childhood. As a result, individuals with ADHD may develop beliefs such as "I never do well in school" or "I never complete projects" as a result of academic- or work-related difficulties. Similarly, struggles in relationships due to symptoms of ADHD such as difficulty focusing on conversations, interrupting others, or general impulsivity may lead to beliefs such as "I'm a terrible friend" or "People don't like me." Importantly, these kinds of beliefs represent misinterpretations of reality or at least extreme exaggerations.

As with CBT for other conditions, the process of identifying unhelpful thinking patterns increases awareness of how thinking patterns influence both behaviors and emotions. This increased self-awareness then leads to the ability to challenge and adjust particular thoughts, thereby leading to associated changes in behaviors and emotions over time. Common tools and techniques used in this process include (among others) Socratic questioning (in which the therapist questions the beliefs or assumptions voiced by a client in order to help shift these beliefs and assumptions in a more helpful direction), instruction in recognizing common "thinking errors," and the use of thought records to record, assess, and challenge thoughts.

24.2.3.1 Socratic Questioning

The use of Socratic questioning is certainly not unique to CBT, but the use of this technique is important for several reasons. First, this technique creates an interactive dialogue between the therapist and client. For example, if a client expresses the belief that "I'm a mess, and everyone knows it," then the therapist might gently question "What does it mean that you're a mess?" and "What makes you say everyone knows it?" This line of questioning is designed to help the client recognize that there are often multiple other ways to interpret or view a situation. Typically, this alleviates distress and helps lay the foundation for generating more adaptive thoughts (e.g., I'm having trouble managing things right now as a result of having many responsibilities).

24.2.3.2 Identifying and Categorizing Unhelpful Thoughts

One common technique used in CBT is to identify the particular automatic thought triggered by a situation, then categorizing this thought into one of a number of groups or classes of "cognitive errors." For instance, common types of cognitive errors include all-or-nothing thinking (viewing things in extreme terms), jumping to conclusions (making assumptions about how events will play out or making assumptions about what others are thinking or feeling), and overgeneralization (viewing singular events as indicative of some general fact).

24.2.3.3 Thought Records

Another technique used in cognitive restructuring is thought records. In its simplest form, this includes listing three columns on a piece of paper: one for the situation, one for the automatic thoughts triggered by the situation, and a final column for behaviors and emotions occurring after the thought. This process allows an examination of how situations can trigger a series of automatic thoughts. In turn, these thoughts contribute to emotions and influence behavior. Teaching clients how to complete a thought record helps illustrate connections between thoughts, emotions, and behavior. Further, it allows for the process of challenging and modifying unhelpful automatic thoughts. Once clients know how to identify automatic thoughts, additional columns can be added to the initial three. These columns provide a place to record more helpful, adaptive thoughts to replace the unhelpful automatic thoughts. Finally, clients can assess how these adaptive thoughts impact later behavior and emotions.

24.2.3.4 Connections to Behavioral Techniques

Finally, although we have discussed behavioral and cognitive techniques in separate sections, the use of these strategies can and should overlap. This is not surprising, given the emphasis on connections between thoughts, feelings, and behaviors that is inherent to CBT. Nevertheless, it warrants a specific explanation.

For instance, cognitive techniques can be key to helping someone actually engaging in the use of many of the behavioral strategies described above. For example, when facing a large, complex task that will require focusing for a long period of time, an adult with ADHD may have thoughts such as “this will take too long” or “this is going to be so boring/unbearable.” Given the difficulties with focusing/sustaining attention that are at the heart of ADHD, such thoughts are understandable. However, they are not *helpful*. These thoughts increase the likelihood that the individual will avoid the task entirely, put it off until the last minute, or rush through it to get it over with as fast as possible.

How might cognitive techniques help with the situation described above? A therapist utilizing cognitive techniques/strategies might help a client with ADHD first identify the underlying belief that is likely at the root of thoughts such as “this will take too long” or “this is going to be so boring.” These thoughts might reflect beliefs such as “I can’t do this” or “This is too much for me” or even “I’ve never been able to do things like this.” Then, a therapist can challenge these thoughts with the use of Socratic questioning (i.e., “Is it really true that you can’t do this?” or “Is there truly no way for you to accomplish this task?”). They might also help the client categorize these thoughts as overgeneralizations or jumping to conclusions.

Similarly, it is important to acknowledge that the behavioral strategies discussed in the prior section will also serve to influence thinking patterns. For example, engaging in these types of behavioral skills can serve as “evidence” to help challenge unhelpful thinking patterns. For instance, a client who reports “I always wait until the last minute” can be encouraged to challenge this belief by using the behavioral strategies described above to get started on a task ahead of the deadline. From a broader perspective, changing patterns of behavior represent new learning, which in turn influences cognitions.

Regardless of the specific technique, the ultimate goal is to adjust these kinds of thoughts and generate more adaptive, helpful thoughts. For instance, a more helpful and balanced thought might be “This is a challenge that may require more planning than usual” or “It’s going to be hard, but I’ve done hard things before.” Over time, a client with ADHD is able to more easily and independently challenge their thoughts “in the moment” and shift toward more balanced, helpful thinking patterns. This in turn allows them to better utilize the behavioral strategies described above, such as breaking tasks down into subtasks, planning out particular days and times to complete certain steps, and blocking time to work on specific tasks. Thus, tendencies to avoid, procrastinate, or rush through tasks can be reduced. In the long term, this both reduces impairment and builds a sense of confidence in one’s ability to successfully accomplish tasks and goals. This self-confidence can be a momentous resource that allows someone to effectively navigate times when they face increased challenges, which are an inevitable part of life. This brings up a related point - CBT as a treatment approach fosters the building of self-awareness and insight.

24.2.4 Enhancing Insight and Self-Awareness

Insight and self-awareness are not commonly discussed in CBT research. However, these factors are often natural by-products of CBT intervention, even without explicit identification (for a more detailed discussion on this topic, see Grosse Holtforth et al., 2007).

For instance, psychoeducation can serve to increase knowledge and awareness of symptoms and their impact on various areas of life. Further, the emphasis on practice that is key to CBT requires engaging in implementation of strategies (both behavioral and cognitive). These processes have the natural effect of facilitating self-awareness and increasing insight.

Moreover, many CBT treatment protocols for ADHD in adults include sessions focused specifically on maintenance – demarking a shift from introducing new material to a focus on effectively sustaining the use of both cognitive and behavioral skills learned in treatment. At this stage, the goal is to support the client’s transition to an increasingly independent role. By specifically encouraging this shift, CBT helps promote increased self-awareness and insight. Further, these can serve as powerful tools in promoting ongoing management of ADHD.

Throughout life, an individual may face periods of greater stress or change. During such times, symptoms are more likely to cause problems as challenges increase. Higher levels of insight and self-awareness results in more effective recognition of such challenges, which in turn allows for more effective management of the same. Finally, the process of navigating such challenges can result in additional learning and self-awareness.

24.3 Conclusions

The basic principles of CBT and key characteristics of this treatment make this treatment a strong fit for the treatment of ADHD in adulthood. In addition, there is ample evidence to support the use of CBT to treat ADHD in adults. CBT has been tested in a number of formats (individual, group, and combined) and the bulk of the evidence suggests this treatment is effective in treating core symptoms and difficulties associated with ADHD. Evidence is particularly strong for the use of CBT combined with medication. This treatment should be considered a primary option when considering psychosocial treatments for adults with ADHD.

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25 Mindfulness Interventions for ADHD

Carlin J. Miller

As described in detail elsewhere in this volume, attention-deficit/hyperactivity disorder (ADHD) is a common lifelong neurodevelopmental disorder that typically presents in early and middle childhood (American Psychiatric Association, 2014) and continues across the lifespan in many people (Barkley et al., 2006). Core symptoms of impulsivity, hyperactivity, and inattention impact academic performance, interactions with peers, and school functioning (American Psychiatric Association, 2014). And related symptoms, including emotion dysregulation and executive dysfunction, increase the difficulties that a person with ADHD manages (Sjöwall et al., 2013). In total, ADHD impacts functioning across the lifespan and increases the risk for poor outcomes, including substance misuse, underemployment, incarceration, and premature death (Kuriyan et al., 2013; Trampush et al., 2009). Thus, finding effective treatment that is accessible, affordable, and tolerable is critical to the functioning of people with ADHD.

25.1 Care Crisis in ADHD Treatment

Empirically supported treatment for most people with ADHD has been available since the 1970s or before in the form of psychostimulant medications. Although these medications are effective in treating the core symptoms of ADHD in most people (Swanson & Volkow, 2009), they are not necessarily effective for ancillary symptoms and are associated with significant side effects for some individuals (Frank et al., 2015). Following these issues, multiple psychosocial treatments, such as behavioural parent training, have also been shown to be effective for some people with ADHD (Watson et al., 2015). Yet not all individuals with ADHD experience adequate improvement with empirically supported treatment, and some are unwilling to use these treatments on an ongoing basis (Charach et al., 2006). This is particularly problematic for people with comorbidities and more complex presentations.

Non-compliance or non-adherence with empirically supported treatment is a widely acknowledged problem, and it extends well beyond ADHD treatment. In some cases, non-adherence exceeds 50% of patients with ADHD who are treated (Adler & Nierenberg, 2010). Factors predicting adherence include parents' beliefs in the efficacy of medication, teacher's beliefs about medication, socioeconomic status, access to insurance in the form of prescription drug coverage, the experience of side effects, and a general trust in the medical system (Zheng et al., 2020). Adherence to treatment is not stable over time (Brinkman et al., 2018). Generally, the more accepting the parent and patient are of the need for treatment, the

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higher the likelihood of adherence (Brinkman et al., 2018). Adherence to treatment is a challenge for some families, particularly when parents and other adult family members also have this highly heritable disorder and this is true for both stimulant medication and behavioural approaches (Friedman et al., 2020). And poor symptom management is frequently cited as a result for discontinuation (Schein et al., 2022). Thus, empirically supported, mainline ADHD treatments are not necessarily easily implemented.

In some cases, the issue is parental opposition to psychostimulant treatment. There is not one specific issue cited by parents in an extensive literature base. Some parents are opposed to using medication to treat a behavioural disorder (Yeh et al., 2014). In other cases, parents are concerned that early exposure to stimulants may lead to an increase in risk for substance misuse. Notably, empirical data do not suggest that this is accurate and stimulant medications are not causally related to later substance problems (Harty et al., 2011). Parents often report side effects with stimulant medications are a major factor in discontinuation (Coletti et al., 2012; Khan & Aslani, 2019). In sum, parents substantially impact the likelihood that a child with ADHD receives medication treatment.

Patient non-compliance with medication treatment has also been highlighted as a reason for poor treatment adherence. Patient acceptance of treatment is a critical factor in adherence (Brinkman et al., 2018). Some patients either refuse medication initiation or desist prematurely out of a desire for self-expression or autonomy (Khan & Aslani, 2019). Higher levels of antagonism, decreased self-control, and increased negative affect have also been cited as reasons patients refuse treatment (Emilsson et al., 2017). The experience of "not feeling like themselves" on medication is often a factor in medication discontinuation (Frank et al., 2015). As a result, even older adolescents and adults with ADHD who have insight about the disorder and its impact on their functioning do not necessarily adhere to empirically supported treatment.

In response to these issues in treatment adherence, there has been an enormous focus on identifying and validating treatments that may be alternative in nature. Unfortunately, this has resulted in the use of ineffective treatment that may divert resources away from more efficacious treatment (Barkley, 2016). Although neurofeedback has been widely advertised in popular media as effective in improving ADHD symptoms, it has not been shown to be as effective as stimulant medication and may be wholly ineffective (Van Doren et al., 2019). Restrictive diets are challenging to implement and show limited efficacy when basic nutritional requirements are already being met (Millichap & Yee, 2012). Alternative treatments like hippotherapy, sand play, and aromatherapy have been clearly shown to be ineffective (Yang et al., 2021), yet parenting magazines and social media are rife with personal testimonials about their efficacy. This results in yet another challenge in the offices of physicians and psychologists as they work with individuals with ADHD and their loved ones.

Beyond the use of ineffective treatment, several options have been identified as complementary treatment for ADHD, and some have been shown to be effective for some individuals. For example, studies have suggested that exercise may improve core symptoms, particularly attention problems (Neudecker et al., 2019), yet the long-term effects of exercise on the functioning of people with ADHD are less clear (Jeyanthi et al., 2021). In other studies, increased involvement in physical activity does not predict symptom improvement (Peralta et al., 2018). Support for neurocognitive interventions is equally mixed (Chacko et al., 2014), yet these also remain popular with parents of children with ADHD. Micronutrient supplementation holds promise with studies using randomly controlled trials demonstrating that attention, overall functioning, and emotional regulation improve with these specialized vitamin and mineral packages (Rucklidge et al., 2018), but the long-term impact is yet to be established and the financial commitment can be quite high. Meta-analyses of studies on the efficacy of omega-three supplementation also show mixed results (Abdullah et al., 2019; Chang et al., 2018). Sleep problems are common complaints in families of children with ADHD, but studies implementing sleep-focused interventions often suggest the problems are more related to difficult parent–child interactions rather than poor sleep quality per se (Corkum et al., 2001). There are additional intervention modalities often studied with ADHD, but all yield similar mixed results and obstacles.

For the reasons described above, there is a need for supplementary treatment and extra support for families of people with ADHD. Typically, the intervention provided to people with ADHD focuses on the individual. Although this is a critical component in the promotion of competencies and improvement in functioning for the individual, the interventions rarely promote the coping of others in the environment. Family members clearly want to actively help their loved one with ADHD function on a higher level (Ruuskanen et al., 2019). With the broad interest in meditation and evidence supporting its use, mindfulness training for people with ADHD and their families has received increased attention over the last decade.

25.2 What Is Mindfulness? What Is Mindfulness Training?

Mindfulness as a state, a trait, and a mode of intervention is rooted in traditional Buddhist philosophy that is thousands of years old in its formation. Additionally, many religious and cultural traditions, including labyrinth walking and repetitive prayer, are contemplative in nature and may have similar associated benefits (Farb et al., 2015). Although mindfulness practices are closely linked with particular religious traditions, many of the interventions that include mindfulness are fully secular when implemented with clinical and non-clinical populations (Grossman & Van Dam, 2011). When used in a secular context, mindfulness as a construct is typically separated from the *dharmic* teachings that are central to Buddhist practices.

Mindfulness as a State and a Trait Mindfulness is a state that all humans experience (e.g., Baer et al., 2008). It is simply being with what is happening at a particular point in time without focusing one's thoughts or feelings in a particular way or wanting to change the experience. Experiences like noticing the scent and warmth of clean laundry coming out of the dryer or observing the colours and quiet of a sunset may produce mindfulness. What is absent in these mindful experiences compared with other ways of being is the individual is not thinking about, ruminating upon, or wishing the experience to be different in some way. As a result, the focus remains on the unjudged present, not the remembered past or imagined future.

Notably, experiencing a moment of mindfulness does not necessarily require previous training or regular contemplative practice. Yet, it is also amenable to change resulting from mindfulness training and dedicated practice over time (Smalley et al., 2009). Studies indicate that those who meditate regularly and for longer periods of time experience states of mindfulness more frequently. The state of mindfulness is typically considered to be antithetical to sustained negative emotional states and ruminative distress (Hill & Updegraff, 2012). But it is not a state that can be pursued or sought out; it is the act of being rather than doing that results in a mindful experience.

The more often an individual experiences mindfulness as a state, the more trait-like it becomes. This may reflect a continuous and perhaps normal distribution with some people experiencing mindfulness almost never and an equally small number experiencing long periods of mindfulness (Karl & Fischer, 2022). Those with more frequent mindfulness experiences (i.e. those who have greater trait-like mindfulness) have been shown to have better mental health, greater resilience to stress, and reduced difficulties in coping (Karl & Fischer, 2022). These individuals typically have a regular meditation practice and are often quite advanced in the amount of time they devote to practice (Strohmaier, 2020). Studies with Buddhist monks with extensive meditation experience suggest that mindfulness as a trait has been associated with higher-order cognitive and sensory changes, as well as changes in the functioning of the autonomic nervous system (Hankey, 2006). Following this research and a multitude of related studies, more mindful individuals are better off than less mindful individuals in many ways.

Mindfulness as a Component of Clinical Interventions In the 1970s, medical and allied health professionals began to develop programming that used contemplative practices to alleviate suffering and reduce stress. One of the earliest of these was mindfulness-based stress reduction (MBSR), which was developed by Dr. Jon Kabat-Zinn and colleagues at the School of Medicine at the University of Massachusetts (Kabat-Zinn, 1982). Although initially developed and validated for use with people with chronic pain (Kabat-Zinn et al., 1985), it rapidly caught the attention of many health practitioners and people in various clinical populations. In the context of a clinical intervention, mindfulness is described as intentionally paying attention to the experience of the present, including bodily, cognitive, and emotional experiences without criticism or rumination (Kabat-Zinn, 2013). In these models of intervention, the individual is taught to be curious and accepting of whatever is in their awareness (Bishop et al., 2004).

MBSR (Kabat-Zinn, 2013) is an intervention delivered in a group context and has four basic components: body scan, attention to the breath, physical exercise focused on bodily sensations, and bringing awareness to daily activities. Body scan involves focusing attention on a specific body part, noticing what sensations are present, and then releasing attention before moving on to another body part. This practice allows the participant to anchor their attention while practicing observation in a detached, non-judgmental state. Attention to the breath provides another anchor point in consciousness, with the participant noticing their breathing without judgment or an attempt to change the breath. Physical movement practices in MBSR include walking meditation and gentle yoga practices. With movement practices, the goal is to observe sensations in the body, noticing the thoughts and feelings that arise as the body moves. The cultivation of awareness in daily activities engages the individual in becoming aware of the thoughts, feelings, and sensations that arise as one completes activities of daily living, such as household chores or eating. MBSR and related programmes are typically delivered over eight weekly sessions with each session lasting 2–2.5 hours. There is often a day-long silent retreat between the sessions in weeks six and seven. There is also an expectation that the participant will engage in daily practice for 30–45 minutes at home across the intervention, often using instructor-provided audio files. There have been many studies validating the use of MBSR with a range of clinical populations and typically developing individuals (Bohlmeijer et al., 2010; Fjorback et al., 2011; Khoury et al., 2015), with evidence for reduced stress, distress, and somatic health complaints in the context of increased well-being and quality of life.

Following MBSR, multiple programmes have been developed with modifications to better meet the needs of clinical populations using a transdiagnostic approach (Khoury et al., 2013). Over the decades since MBSR was validated and expanded, the clinical community has integrated mindfulness-based programming into an integrative approach to health care and into third-wave psychotherapies (Hayes et al., 2004). For example, Mindfulness-based Cognitive Therapy was developed to meet the needs of people with recurrent major depressive episodes more effectively (Sipe & Eisendrath, 2012). Likewise, Dialectical Behaviour Therapy (Lynch et al., 2006) includes mindfulness as one of its core elements in treating borderline personality disorder and related problems. Whether a dedicated mindfulness training programme or a manualized intervention that includes mindfulness as a component, there is substantial evidence to support the use of mindfulness in multiple therapeutic contexts.

Clinical outcomes associated with mindfulness-based interventions have been demonstrated using both self-reports and physiological indices. Data from empirical studies suggest that individuals who receive mindfulness training are better able to regulate their affect (Tacón et al., 2003), have improved behavioural control (Brown & Ryan, 2003), are less likely to respond with automatic behaviours (Schultz & Ryan, 2015), experience reduced levels of distress in response to social problems (Vibe et al., 2012), and have improved insight (Davis & Hayes, 2011). Furthermore, the process of focusing attention and then refocusing after distraction may lead to reduced mind wandering/distractibility (Feruglio et al., 2021). Results of functional imaging studies (Marchand, 2014) suggest that mindfulness training improves the ability of prefrontal cortex to inhibit amygdala action in response to negative affect, thus reducing automatic, anxious, or ruminative states. Furthermore, it appears that more mindful individuals recover more quickly from negative mood states (Broderick, 2005). Yet, these interventions are sometimes criticized for being time-intensive, difficult to access outside of large urban centres, and expensive for participants. Based on the positive outcomes associated with mindfulness training for many clinical populations, it is not surprising that it has been frequently sought out by many in the ADHD community. And there are documented benefits for those individuals with ADHD who engage in regular mindfulness practice, including improved mental health, enhanced self-compassion, and greater self-reported self-control and inhibition (Geurts et al., 2021).

Contraindications for Mindfulness Training Before presenting information supporting the use of mindfulness training with a clinical population, like individuals with ADHD, it is important to consider the reasons why it may not be an appropriate choice for all people. There is a substantial body of research that suggests that individuals enrolled in mindfulness training interventions frequently quit before the intervention is completed. One of the most significant reasons for this is the time commitment involved in learning to meditate (Salmon et al., 2009). Those benefitting from mindfulness training across clinical groups typically report extended daily practice over a matter of months. This level of commitment requires a very high and sustained level of motivation to change, an issue that has been highlighted as a pitfall in many interventions for ADHD (Weiss et al., 2008).

In addition to issues of poor fit, there are scenarios where mindfulness training is contraindicated. It has been noted that for people with very severe psychological problems or with psychosis, mindfulness interventions may increase symptoms and result in an overall decline in functioning (Kuijpers et al., 2007). Because mindfulness meditation brings all experiences, both positive and negative, into awareness, this form of intervention may increase distress even in people who are not acutely unwell (Dobkin et al., 2012). Other studies have indicated that mindfulness interventions may result in increased symptom awareness and severity in affective and anxious disorders (Lustyk et al., 2009). Finally, there are multiple studies to support the need for creating trauma-informed mindfulness practices for all people (Burrows, 2016). This is particularly important for people with ADHD as there is evidence to suggest that this clinical population experiences higher than expected rates of trauma-related disorders (Biederman et al., 2014). Thus, it is critical that individuals with ADHD receive a thorough assessment of their ADHD symptoms as well as their comorbid psychopathology prior to beginning any form of mindfulness training.

25.3 Targeted Mindfulness Training for People with ADHD

Like most of the transdiagnostic mindfulness interventions, programming for people with ADHD typically occurs in a group format, although more individualized approaches are also available. Most of this programming has been somewhat modified to meet the specific needs of people with ADHD and in some cases includes psychoeducation about ADHD. The core mindfulness training components are typically present but may be modified to fit the experience of people with ADHD. For example, there are five major elements that should be included in any mindfulness programming: awareness of the activity of the mind, non-judgment, acceptance and letting go, "beginner's mind", and being present to experience. For a person with ADHD, the awareness of the activity of the mind typically involves teaching that the mind frequently and spontaneously wanders and the goal of mindfulness is to train it to return to the point of focus at will. The assumption is that with additional practice in noticing the wandering mind and repeated returns to focus, the individual has better attentional skills. For a person with ADHD, the mind is even more prone to wandering (Ostojic-Aitkens et al., 2019) and this wandering may be more likely to occur outside the awareness of the individual, resulting in a sense of helplessness and inability to redirect focus. Therefore, it may be helpful for mindfulness interventions to provide more practices that address distraction and non-judgmental self-redirection. Self-judgment in the form of harsh criticism is common among people with ADHD (Beaton et al., 2020); thus, a self-compassionate approach to redirection is important. For many people with ADHD, who are also at risk for higher levels of neuroticism and lower levels of agreeableness (Miller et al., 2008), specific emphasis should be placed on the role rumination and poor self-concept may play in ADHD, particularly when comorbid psychopathology is present. Relatedly, people with ADHD may be more prone to rumination or "getting stuck" (Mitchell et al., 2013). Thus, the emphasis on letting thoughts go is particularly appropriate but is likely to require substantial instruction and practice. The concept of "beginner's mind" may specifically appeal to some individuals with ADHD as they can be prone to paradoxical intense focus on a particular thought or experience, while missing other important aspects of their experiences. Thus, a greater integration of "beginner's mind" with focusing on the present moment may be needed for people with ADHD. Overall, the fit of mindfulness tenets is theoretically well-placed with ADHD intervention.

Although the key tenets remain intact, modifications in practice are key for individuals with ADHD to benefit from mindfulness training (Leeth et al.(2019) provide an excellent and detailed review of this work). For example, people with ADHD may benefit from additional practices and more exemplars of focusing on concrete experiences, such as the breath. The instructor may need to offer more guided practices with the breath or may need to offer more frequent reminders to keep participants with ADHD focused on the breath. Over time this should be reduced to allow for generalization to independent practice, but that additional support should be given as long as needed. Likewise, emphasis on practices with frequently changing foci or concrete supports, such as "square breathing[1]" or "starfish breathing[2]", may be a better fit for people with ADHD compared with practices that involve simply observing the act of breathing. The length of practices and sessions should also be considered. Individuals with ADHD would likely benefit from shorter meditation practices that are consistently attempted across the day. Many earlier models of mindfulness training were heavily focused on extended seated meditation and other still practices, which may be a poor fit for people who have higher levels of physical activity and impulsivity. Thus, people with ADHD may benefit from a greater emphasis on

[1] The "square breathing" practice involves visualizing a square as one breathes. The focus of the attention is on the experience of the breath. On the in-breath, the person traces (with their finger in the air or in their mind) the far left side of the square from bottom to top. Retaining the inhaled breath corresponds to the top of the square from left to right. On the out-breath, the person follows the square from the top right corner to the bottom right corner. The exhaled breath is retained across the bottom of the square and then the cycle starts again. Typically, this practice is done slowly and evenly.

[2] "Starfish breathing" anchors the breath on the tracing of the outline of the individual's hand. Using the right hand to trace the left hand starting near the wrist and moving upward towards the pinky, the person breathes in. At the top of the pinky, there is a brief noticed pause and then the individual exhales tracing down to the space between the pinky and ring fingers. When that space is reached, there is again a brief noticed pause and then the inhale starts again as the individual traces up the ring finger. This breathing is continued as the person traces the entire hand, perhaps reversing course repeatedly at the pinky and thumb sides of the wrists.

movement- or sensory-based practices, such as walking meditation or engagement with particular sensory experiences (e.g. mindful eating). For some individuals, particularly those with significant attentional difficulties, shorter, highly structured sessions with clear agendas and homework assignments are necessary for engagement in mindfulness training. Relatedly, daily practice is a common element across mindfulness training programmes. For individuals with ADHD, it may help if they involve others in their daily practice. For children, parents can practice with them each day and support a quiet environment for meditation practice. For older adolescents and adults, they may benefit from a friend or significant other being involved in their daily practice as an accountability partner. None of these modifications are antithetical to mindfulness training as it was initially described in MBSR and may support greater engagement in mindfulness practice for those with and without ADHD.

As noted by multiple researchers, there are several key considerations in the provision of mindfulness training for people with ADHD. All programmes require sufficient human resources. This includes instructors who have stable, ongoing, and authentic mindfulness practice of their own. When the target group includes people with ADHD, it is critical that the instructors also understand how ADHD symptoms may impact engagement in mindfulness-based interventions. Because psychoeducation about ADHD for participants is often a key component for this target group, it is also important that the instructor has detailed knowledge about ADHD, including prevalence, symptoms, associated difficulties, comorbidities, and long-term outcomes. Thus, the instructor for mindfulness training for people with ADHD requires additional preparation and experience well beyond what the typical clinician or instructor brings to teaching mindfulness groups. In addition to the human resources, logistics such as time, space, and personnel to run multiple groups may also play a role in scheduling programming. For example, as described below, providing mindfulness training to parents and their children in overlapping, parallel sessions may support the best possible outcomes for participants, but this requires additional physical space and personnel resources that are not as pressing when groups do not run in parallel. This relates to an additional point of consideration --- buy-in by parents/significant others and people with ADHD. In order to be willing participants in the process, parents and/or significant others in the life of someone with ADHD must have experience with meditation, which is time-intensive and may be costly. Without that, the stakeholder may struggle to empathize with the person who is engaged in mindfulness training and cannot provide adequate support for the practice, which is particularly important at points when learning to be more mindful becomes more challenging. Likewise, people with ADHD often describe waxing and waning motivation for any change (Smith & Langberg, 2018). It should be expected that this is also true as they learn to meditate through daily practice and weekly session attendance. Additionally, as is the case with all forms of child and adolescent-focused interventions, participant motivation to improve in functioning and overall symptom presentation in the offspring may be lower than in the parent who enrolled them in mindfulness-based intervention.

Mindfulness Programming for Children and Adolescents and their Parents As noted previously, mindfulness training for children is most effective when it is runs in parallel with comparable training for parents. One of the best known and widely investigated mindfulness training programmes for children with ADHD and their parents is the MYmind programme (Siebelink et al., 2018). Originally developed in Europe, it has been validated in multiple settings around the world and in many published empirical studies. In this intervention, children and adolescents attend weekly sessions for 8 weeks at the same time their parents are receiving parallel intervention. Programming includes psychoeducation about ADHD, guided meditation practice, crafts, and group discussions. This programme has been tested in multiple random control trials with active control and waitlist control conditions. Typically, by the end of the programme, there are improvements in ADHD symptoms, but these effects may be diminished or absent over time. The impermanence of these improvements may be the result of poor adherence to ongoing mindfulness practice. Improvements in child executive functioning and parental over-reactivity have also been noted in MYmind studies (Bögels et al., 2021). In some cases, parents remain more mindful in their parenting practices and have ongoing improvements in their own ADHD symptoms at longer term follow-ups (Siebelink et al., 2022). Notably, when parents also have ADHD (particularly fathers), the lasting impact on their parenting and parenting stress is even greater (Bögels et al., 2021). When this programme was tested in a Hong Kong sample, there were improvements in performance on objective measures of attention in the children with ADHD, but parents' rating of symptoms and impairment was not changed (Zhang et al., 2017). In a study that provided a different mindfulness-based intervention to younger children (ages 5–7 years) with ADHD and their parents using a waitlist control design, child ADHD symptoms improved as parental stress and well-being improved (Lo et al., 2020). Thus, it appears that the provision of mindfulness training to children with ADHD and their parents is effective in at least some contexts.

When mindfulness training is provided to only the child/adolescent with ADHD, improvements are more challenging to demonstrate. For example, in a trial that compared mindfulness training with a behaviour therapy programme in a summer programme for children with ADHD, there was no difference between the intervention groups in behaviour, attention problems, inhibitory control, or mindfulness (Ramos et al., 2022). Similarly, in a programme that provided mindfulness training to children with ADHD, improvements were seen in dysregulation but there were no significant changes in ADHD symptoms at the end of the programming (Huguet et al., 2019).

Why mindfulness training is less effective when only children receive the intervention is likely multifactorial. Many of the published studies represent work that is still developing with interventions that are based on multiple protocols and programmes. Thus, these interventions are likely not taking advantage of best practices information that has been developed in the programmes that involve parents and children. In some cases, the studies do not utilize an active control condition with random assignment which means the results are not necessarily valid. Parents who do not have their own stable practice of mindfulness may not be able to support their child with ADHD in their daily practice at home. Thus, the child with ADHD may struggle with practice and parents cannot provide the needed assistance. Overall, the use of mindfulness training for children and adolescents with ADHD when parents are not receiving comparable intervention is less likely to be effective.

Because there have been a growing number of published studies on mindfulness programming for children and adolescents with ADHD, meta-analyses combining results across studies are also being published. Results from this work suggest that there are benefits to mindfulness training for children and adolescents with ADHD, but it should not be considered a replacement for empirically supported treatments such as medication (Oliva et al., 2021). For example, one meta-analysis showed improvements in attention and impulsivity with mindfulness training for children, but there is also clear evidence of publication bias (Cairncross & Miller, 2020). An earlier meta-analysis showed improvements in ADHD symptoms, parent−child relations, on-task behaviour, and child executive functioning as well as decreased parental stress and increased parental mindfulness (Chimiklis et al., 2018). Yet, these authors also noted there were major limitations in how the studies included were designed and there was evidence for publication bias. A recent meta-analysis using only randomly controlled trials reported substantial improvements in ADHD symptoms over the course of the mindfulness training programmes, but these were typically not maintained 1–6 months later at follow-up (Lee et al., 2022). Notably, this study also reported that the benefits of mindfulness training are greater for older children and adolescents than young children. In summary, results from research on mindfulness training for children are mixed, and this form of intervention requires substantial investment by clinicians and parents. Further, it is clear that mindfulness training should not be provided in lieu of more established treatments for childhood ADHD, such as stimulant medication and parent training.

Mindfulness Programming for Older Adolescents and Adults with ADHD Like the mindfulness programming developed for children with ADHD, there have been specialized mindfulness-based interventions developed for adults with ADHD. For example, one randomly controlled trial with 120 adults used Mindfulness-based Cognitive Therapy as an addendum to treatment-as-usual (medication and/or psychoeducation) with treatment-as usual as the control condition. Results indicated that these participants experienced improvements in their ADHD symptoms (as measures by blinded clinician ratings and self-reports), as well as increased self-reported mindfulness skills, self-compassion, and overall mental health (Janssen et al., 2019). Furthermore, the results were maintained from the end of the intervention through to follow-up. Results from a feasibility trial of an eight-week mindfulness training programme specifically developed for adults and older adolescents with ADHD (Zylowska et al., 2008) suggested that the participants liked the intervention. Additionally, ADHD symptoms by self-report improved as did objectively measured attention. Notably, participants also reported improvements in their anxiety and depression symptoms. This programme, called MAPs for ADHD, has been used at multiple sites and has been widely published. There are multiple comparable studies that report similar results and efficacy.

With the ongoing interest in mindfulness training for adults with ADHD, several studies using meta-analyses have been published. For example, a meta-analysis using studies with only adults supported the use of mindfulness-based intervention to improve ADHD symptoms, as well as improving executive functioning and emotion regulation (Poissant et al., 2019). These authors noted that the research base, like mindfulness studies focused on children with ADHD, is flawed with limited use of randomization, a lack of control groups, and high attrition bias. Similar results were reported by a later study, with the caveat of mindfulness training probably being better included as a complementary treatment rather than a replacement for other empirically supported treatments (Oliva et al., 2021). The full range of ADHD symptoms, including hyperactivity/impulsivity and attention problems, appear to be improved with mindfulness training, and this training appears to be better suited to adults and older adolescents than children (Cairncross & Miller, 2020). In addition to ADHD symptoms, mindfulness training for adults with ADHD may also improve executive functioning and depression symptoms (Poissant et al., 2019). In summary, the body of research on mindfulness training for adults with ADHD suggests that this may serve as an important component of ADHD treatment but should not be seen as a replacement for other therapies, such as psychostimulant medication.

25.4 Mechanisms of Effect in Mindfulness Training for People with ADHD

As described above, mindfulness training for children, adolescents, and adults may play a role in improvements in ADHD symptoms and overall functioning for some people. Why mindfulness-based interventions improve symptoms of ADHD and functioning of people with ADHD continues to be investigated. There are multiple working hypotheses, but as one might expect with a multifactorial disorder like ADHD, there are few clear answers. When one examines the literature, there are three themes that emerge as proposed mechanisms of action: changes in executive functioning, changes in neurotransmitters, and changes in pathophysiology (Schoenberg, 2016).

Changes in Executive Functioning One of the significant core deficits noted in people with ADHD is difficulties with executive functioning. Specifically, people with ADHD often have difficulty with set or task shifting, with working memory, and with inhibiting prepotent responses (Barkley, 1997). These difficulties lead to problems with performance monitoring and subsequent control of behaviour. It is hypothesized that these difficulties are caused by insufficient or inefficient signalling between the prefrontal cortex and subcortical structures (Miyake et al., 2000). These deficits and difficulties have been described elsewhere in greater detail in this volume.

There is evidence to support the assumption that mindfulness practice is associated with improvements in executive functioning and overall cognitive control in multiple groups. For example, inhibitory control and performance monitoring are improved with regular mindfulness practice (Schoenberg et al., 2014). As the individual becomes more observant and less reactive, they are better able to respond less impulsively. With mindfulness training and with sustained mindfulness practice, working memory often improves and there is less frequent mind wandering (Mrazek et al., 2013). In essence, as the individual becomes more aware their mind wanders, they redirect their attention more quickly and with fewer consequences. Other studies have indicated that mindfulness training improves affective self-regulation and sustained attention (Wimmer et al., 2020). It is through the non-attachment to thoughts and feelings that the individual becomes better at focusing attention on the present moment. Unfortunately, little of this research linking mindfulness practices and executive functioning has focused on mechanisms of action or directions of effect.

Although the direction of effects is not clear (i.e. do the changes in executive functioning result from or result in improved ADHD functioning or is there another underlying variable/s?), the research clearly demonstrates an association between improvements in executive functioning in many people with ADHD and receiving mindfulness training. For example, one meta-analytic study showed that adults with ADHD had significant improvements in executive functioning following mindfulness interventions (Poissant et al., 2020). In a study with children who received mindfulness and exercise-based interventions over multiple days, there were improvements in executive functioning only in the mindfulness condition (Bigelow et al., 2021). Notably, these improvements were measured using clinical assessments of executive functioning, including measures of inhibitory control, working memory, and task switching. In contrast, in a sample of adults with ADHD who received longer term mindfulness training, their performance on executive functioning tasks did not increase but self-reports and clinician ratings of executive functioning improved significantly (Mitchell et al., 2017). These authors also noted that there were substantial improvements in emotional regulation, which may be related to executive functioning. In summary, whether changes in executive functioning are the mechanism of action for improvements in people with ADHD is not yet clear, but there is substantial evidence for mindfulness training being associated with improved performance monitoring and self-control.

Changes in Neurotransmitters There is substantial research demonstrating differences in multiple neurotransmitters in people with ADHD compared to others (Mehta et al., 2019). For example, people with ADHD have alterations in their levels of norepinephrine, dopamine, acetylcholine, and serotonin (Tripp & Wickens, 2009). Most medications used to treat ADHD and its comorbidities target these neurotransmitter systems.

Although there are no studies yet that link changes in these neurotransmitters with improvements in ADHD symptoms following mindfulness training, there are a small number of studies demonstrating this link with people in other clinical populations and neurotypical individuals. For example, it has been shown that following mindfulness training, individuals have changes in serum cortisol and norepinephrine (Moraes et al., 2018). Another study showed persistent changes in serum norepinephrine and dopamine a year after mindfulness training in those individuals who continued their practice (Grazzi et al., 2019). In a study that used spontaneous eyeblink as a correlate of dopamine activity, long-term meditation practice was linked to lasting changes in dopamine activity (Kruis et al., 2016). Future research investigating the underlying mechanisms in mindfulness training for people with ADHD should consider the role neurotransmitters may play.

Changes in Pathophysiology The pathophysiology associated with ADHD has been widely described (Jensen, 2000). Yet, much of the research on changes in the structure and function of the brain with mindfulness training has been with neurotypical individuals and with people with extensive meditation experience, with very little research focused on people with ADHD. Structural and functional differences across the brain in areas ranging from the cerebellum to the prefrontal cortex as well as in broad functional networks have been investigated in people with ADHD. The structures associated with goal-directed behaviour and thoughts, largely in the striatal network including the prefrontal cortex (Giedd et al., 2006) have received significant research attention in ADHD. Likewise, the structures connected to the anterior cingulate cortex, which are part of the default mode network, have been highlighted for their role in attention and processing. These systems work in parallel with the upregulation of the attentional and signal detection systems linked with prefrontal cortex activity resulting in the down regulation of the default mode network (Bauer et al., 2020). In individuals with ADHD, overactivity in the default mode network interferes with focused attention (Bledsoe et al., 2013). There are multiple studies that have demonstrated that mindfulness training and ongoing practice improve the modulation of the default mode network, thereby improving regulation of attentional processes (Hölzel et al., 2011; Taylor et al., 2013). There is also evidence for enhanced prefrontal cortical functioning and associated improvements in emotion regulation and cognitive control after the use of mediation activities (Hölzel et al., 2011). Finally, ADHD symptoms have also been corelated with dysregulation in the hypothalamus-pituitary-adrenal (HPA) axis, particularly with cortisol (Isaksson et al., 2012). It is possible that this dysregulation plays a role in basal metabolic under arousal and therefore the sensation seeking that is commonly problematic for people with ADHD. Regular meditation practice is associated with normalizing cortisol levels (Kim et al., 2013). Thus, there is clear evidence for changes in how the brain functions with ongoing mindfulness practice, but more research is needed to assess the long-term impact on people with ADHD.

In addition to the changes in functional activity in the brain, structural changes have also been associated with mindfulness interventions. For example, long-term meditators have increases in their grey matter density in the prefrontal cortex compared to people who are meditation naïve (Fox et al., 2014; Hölzel et al., 2011). This is particularly notable as reduced grey matter density in these areas have been linked to ADHD symptoms (Carmona et al., 2005) and increases in grey matter density over development have been associated with the remission of symptoms (Luo et al., 2020). It has also been noted that mindfulness training also enhances white matter connectivity, particularly in the default mode network, in people who meditate (Fox et al., 2014). There are numerous studies that demonstrate diminished white matter density in people with ADHD (Luo et al., 2020; Wu et al., 2014). Relatedly, it has been noted that there is enhanced neuroplastic repair and improved myelination with regular meditation practice (Xu et al., 2022). These connections of mindfulness training with structural brain changes in people with ADHD is another area where research needs to be developed.

25.5 Summary

Mindfulness training has received nearly ubiquitous attention. It appears in social media and clinical research as a "cure all" for nearly all that ails modern humans. Individuals with ADHD and their loved ones have been part of that effort. And it is not entirely without merit, especially when mindfulness training is used as a complementary therapy within an ADHD treatment package that includes other effective therapeutic interventions, such as stimulant medication, enhanced functional structure, and behavioural parent training. As described in the previous sections, research evidence has shown that regular (and often time-intensive) mindfulness practice improves cognitive and behavioural control. It also plays a role in reducing activity in the default mode network within the brain, which has been linked with inattention and mind wandering. Mindfulness practice also appears to change grey and white matter structures and networks within the brain, particularly in those areas that have long been associated with ADHD symptoms and associated dysfunction.

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26 Medications for Children and Adolescents with ADHD

Johnny L. Matson

Attention deficit hyperactive disorder (ADHD) is a disorder that historically dates back to Germany and the rhyme about "Fidgety Phil," which appeared in the children's book *Struuwel-Peter: Merry Tales*. It was authored by Dr. Heinrich Hoffman in 1844. Recently, medical records dating even earlier have been discovered describing ADHD symptoms. However, this poem later translated into English was the first document that resulted in a broad impact. Dr. Hoffman notes that Fidgety Phil will not sit still and wiggles and giggles. Since these early reports, ADHD has become a well-known and frequently diagnosed problem for children and adolescents and later adults as well.

Formal widespread diagnosis of ADHD accelerated markedly with the introduction of stimulant medications as a treatment for ADHD in children. For years, the disorder was considered to be exclusively a childhood condition. However, in recent years thinking has changed and now adults are also recognized as experiencing ADHD. Rates of people diagnosed with ADHD, particularly in first-world countries over the last few decades, have continued to rise. Currently, ADHD is believed to be present in 8.4% of children and adolescents between two and 17 years of age (Chang et al., 2020). ADHD is considered to be a multidimensional chronic neurodevelopmental condition. It is also argued that without early treatment, the disorder may lead to long-term symptom presentation which can compromise quality of life. Heredity also seems to be an important aspect associated with ADHD. Estimates based on twin studies suggest that up to 74% of the disorder may be related to heredity (Faraone & Lasson, 2019). Also, males have been diagnosed with ADHD twice as often as ADHD diagnoses in females (Slobodin & Davidovitch, 2019). Controversy exists on whether or not a disproportionate number of females go undiagnosed and/or if males are overdiagnosed. That debate is likely to continue for some time.

As is the case with other neurodevelopmental disorders, such as autism spectrum disorders, intellectual disabilities and and comorbidities are also common. Over half of those persons with ADHD have comorbid mental health issues. Anxiety disorders and oppositional defiant disorders are among the most common of these conditions. The issue of comorbid mental health disorders of course has implications for both assessment and treatment.

26.1 Treatment Overview

It has been repeatedly noted that psychological interventions should be the first line of intervention for ADHD (Chang et al., 2020). This

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approach is particularly important when treating children given their developing nervous system. Having said that, in clinical practice, this recommendation is rarely followed. Rather, medications, particularly stimulants, are used as a first line of treatment. Often these drugs are followed by drugs from other drug classes, and no psychological/educational methods are implemented. Researchers have suggested that between 25% and 90% of children with an ADHD diagnosis are prescribed medication at some point. Additionally, the use of medication is increasing as is polypharmacy (Safer & Zito, 2000). Why is this the case? First, the entry point for an ADHD diagnosis is typically the pediatrician. These professionals may not be particularly familiar with psychological methods relative to their knowledge of pharmacological intervention for ADHD. Also, they may or may not be well versed in methods and procedures to make an accurate ADHD diagnosis. This observation is underscored by the development over the last few decades of a subfield in clinical child psychology called pediatric psychology. These professionals work in a team with pediatricians to provide psychological treatments for common childhood problems such as bed wetting and ADHD. The idea is a good one but given the limited number of pediatric psychologists this model of care is not in widespread use as of this writing.

A second problem is the difficulty in implementation of psychological interventions relative to medication. Psychological treatments require buy in and a lot of effort on the part of the caregiver. Multiple training sessions are needed, and a regimented set of operations in the home environment are required for successful implementation.

On the positive side, long-term treatment effects appear to be stronger for psychological treatments. Clients appear to habituate to medications in many cases, thus mitigating their long-term effects. Also, while some adverse psychological effects such as burnout can occur, medication adverse side effects appear to be far greater. Among these symptoms are loss of appetite, growth delays, cardiovascular risks, tics, substance misuse, sleep disturbances, seizures, suicidal thought, and psychiatric symptoms (Cortese et al., 2013). Having said this, most parents and prescribing professionals believe the positives outweigh the negatives based on high rates of prescription practices. The knowledge base regarding these drug treatments is growing rapidly and is quite extensive at this point. The next section will provide a discussion of how medications are used.

26.2 Drug Patterns

Since the focus of this chapter is on medication use in children and adolescents with ADHD, I start with a discussion of factors associated with medication use. The core symptoms treated are behaviors that make up the general categories of impulsivity, inattention, and hyperactivity. Rates of medication prescription vary internationally from about 1% in Denmark to over 4 ½ % in Canada and Iceland (Dalsgaard et al., 2014; Polanczyk et al., 2007). Researchers also know that, as stated earlier, boys are more frequently diagnosed with ADHD. Also, children with developmental delays are more frequently diagnosed with ADHD. Finally, an age differential is evident as well, with some relatively young children being unnecessarily diagnosed and as a result are prescribed medication (Holland & Sayal, 2019).

Other factors that effect the diagnostic outcome for ADHD are also apparent. The two most common systems are the DSM-5 (North America) and the International Classification of Diseases, currently the ICD-10 (Europe). Unlike the DSM-5, the ICD-10 excludes ADHD for children with comorbid diagnoses of anxiety, pervasive developmental disorder, schizophrenia, mania, bipolar disorder, and depression (Setyawan et al., 2018). Also, with respect to Europe, availability of different medication varies across countries. This factor effects treatment as well.

26.3 Factors Effecting Outcomes

A variety of factors effect how well medications can remediate ADHD in children and adolescents. One of the more important variables is adherence to medication dosing. Adherence has been defined as taking medications as prescribed 80% of the time during the week and 50% of the time on the weekends. Also, complete symptom control and physician satisfaction with treatment are underscored (Setyawan et al., 2018) These latter two factors deserve careful consideration. First, and foremost, how well these two factors are defined is critical. Operational definitions that can be observed and reported reliably across multiple professionals and/or caregivers should be included. Also, data need to be obtained in multiple environments with school and home being the most important. Well-established recording methods, and whether observation or data included via checklists. Rarely does this occur in real life settings, however. Having said that, observing specific behaviors in multiple settings remains the best method for diagnosing ADHD. However, because of the time needed to carry out these procedures and the logistics involved, they are rarely used.

Increasingly, long-term effects are emphasized. For years, ADHD was considered a childhood condition only. Thus, tracking the initial effects was the primary intervention goal. Moving forward, it is really important to emphasize long-term evaluation much more. Given that ADHD is now considered lifelong, it is even more important.

As noted, it is becoming more evident that ADHD continues into adulthood for many people (Biederman et al., 2011). Thus, being able to conduct periodic evaluations is critical for evaluating medication effectiveness. Also, adherence becomes an even more important variable since medications need to be taken consistently and accurately, relative to how the medication (s) are prescribed. Because ADHD diagnosis and treatment is a long and difficult process, adherence is poor in many cases (Charach et al., 2006). Medication nonadherence is frequently the case in children and adolescents with ADHD. At present, considerably more data are available on younger people than adults with ADHD. Nonetheless, adherence issues appear to be the case for adults as well. Finally, the consequence of nonadherence, and the degree of nonadherence (e.g., medication is taken periodically versus not at all) has not been studied (Adler & Nierenberg, 2010).

Some researchers have speculated that children with more severe symptoms of ADHD are more likely to be prescribed medication (Hjern et al., 2010). Certainly, the issue is much more complex than this, and is acknowledged. These authors also posit that children from lower socioeconomic families, exposure to a higher number of stressors and a higher risk of childhood adverse events may also contribute to increased diagnosis (Levine, 2005; Stansfeld et al., 2008). Differences in the structure of health and general agencies have also been noted, and I would add the clinical practices and priorities of the professionals prescribing medication(s) for ADHD. Adherence is also correlated to how often and how long medications have been prescribed. All the factors above can negatively impact adherence. Additionally, cost is a big issue for many families and also effects long-term use (Barner et al., 2011). Beliefs and attitudes about taking medications may effect adherence. Another variable that effects drug adherence is the number and severity of side effects (Charach & Fernandez, 2013). Side effects can vary widely in type and intensity of symptoms. Among the most common of these side effects are decreased appetite, sleep disturbances, headaches, and stomach aches among others.

26.4 Side Effects of Medications

Methyphenidate, dexamfetamine, and atomoxetine are the most widely used medications for treating ADHD in children and adolescents (Graham et al., 2011). These authors, who represent the European Guidelines Group, recommend interventions for children, that use multimodal treatments. However, as noted here, in clinical practice, often the intervention is medication only.

The most eye-catching side effect, although very rare (58.4/100,000), is sudden death. Among these individuals, the number of deaths with an unexplained cause is unknown. Using the adverse events reporting system, researchers note similar rates of sudden death for two medications (dexamfetamine and methylphenidate), 0.6/100,000 per year (Faraone et al., 2008). However, this syndrome is very rare and thus, this data must be viewed with caution.

A second potential concern is suicide ideation, which may not necessarily be related to depression. Additionally, there is a relationship between ADHD and a second condition, which has a strong overlap with suicide ideation, suicide attempts. Again, these data are correlational, and even assuming cause and effect, that may be due to the accuracy of ADHD diagnosis plus comorbid diagnoses such as depression and not medications for ADHD per say.

A more established, less speculative, side effect of stimulant medication is poor growth in children. Where longitudinal data have been collected reductions in both height and weight gain have been reported (Poulton, 2006). The slowed weight gain is more pronounced that growth in height (Swanson et al., 2007). The size of the dose and length of medication use are also likely to moderate these side effects. Other researchers have concluded that no long-term impact on height has been noted even with long-term chronic use. Further, different stimulant drugs had similar effects on growth (Zachor et al., 2006).

Sleep disturbances are also associated with ADHD when stimulant medications are prescribed. Variability and severity of symptoms vary considerably across children and adolescents with ADHD. Dose and the specific stimulant medication prescribed also appear to effect sleep problems such as getting ready for bed, delays in falling asleep, and getting ready in the morning. Additionally, stimulant medications result in decreased sleep efficiency, longer sleep latency, and shorter sleep duration (Kidwell et al., 2015).

All stimulant medications as well as atomoxetine result in increased blood pressure (Wernicke et al., 2003). Also, stimulant medications cause increase heart rate by about one to two beats per minute (Vetter et al., 2008). Of particular concern are risk factors demonstrated by children and adolescents such as positive family history for cardiac disease. Also, a body mass index (BMI) above 95%, and/or known heart disease or defects can also be of concern.

Another potential issue for medication for ADHD is misuse (Clemow & Walker, 2014). Using ADHD drugs for recreational purposes is one problem that can also result in safety issues. For example, increased emergency department visits are one of these outcomes. Other concerns are malingering and dependence. Misuse is primarily apparent in adolescents versus children. When medication is used for purposes outside of medically authorized reasons often these drugs are moved to illegal markets.

Malingering consists of falsely claiming symptoms that are not present and/or dramatically exaggerating existing symptoms. The purpose of this behavior is to obtain medications for illegitimate use. Monetary cost is entwined with this issue. Unnecessary doctor visits, emergency department treatment, rehabilitation costs, human turmoil, and of course the cost of unnecessary prescriptions are at play. Unfortunately, these problems are common. Adolescents and young adults are generally motivated by the opportunity to "get high." Additionally, students often take these drugs for enhanced academic performance with increased concentration, and alertness during long periods of pretest studying. Other drug use is also common for persons who abuse stimulant medications. Among these drugs are tobacco, alcohol, and marijuana.

26.5 Practical Considerations

Medications for ADHD in children and adolescents is very popular and its use continues to grow, both in the number of persons medicated and in the use of multiple medications for a given individual. These drug combinations are generally considered to be both well tolerated and effective (Clavenna & Bonati, 2017).

Among the most used of the ADHD drugs are methylphenidate (MPH) and dextroamphetamine (DEX). They have similar effects and are both available in short, medium, and ER formulations. Some of the factors that effect the clinician and parent drug choices include how readily can the medication be administered, how long the dose lasts, and what does it cost (Feldman et al., 2018). Also, the issue of adherence is very important. Usually, one dose per day versus more doses results in better adherence. Lower adherence to prescriptions is related to older age and/or with having more learning problems mood disorders or various behavior problems.

In addition to MPH and DEX, several other stimulant and nonstimulant medication are prescribed for ADHD. Among these drugs are Concerto, Biphentin (MPH-HCI, controlled released capsules), generic MPHER, Ritalin SR, Amphetamine/Dextroamphetamine, Vyvanse Lisdexamphetamine dimesylate, Adderall XR mixed amphetamine salts, Dexedrine spansule, Strattera (Atomoxetine HCI), and Intuniv XR (Guanfacine XR). The number of medications and the continued development of additional medications, and medication variants, point to the incredible amount of money spent on these ADHD medications.

Dosing is a major issue that has been addressed for children and adolescents with ADHD. It has been recommended that drug administration should be individually evaluated. This goal is executed best by careful titration to the lowest effective dose. Perhaps this goal can be conceptualized best within a therapeutic window. The notion is that a dose below the therapeutic window will not produce optimal effects on targeted ADHD symptoms. However, once the dose goes above the top of the therapeutic window the result may be a greater number of adverse side effects. Close monitoring and data collection by parents, teachers, or clinicians is strongly recommended. The frequency of data collection should be higher when medication is first prescribed and should be continued until an optimal dose has been reached. The monitoring should still be performed but less frequently once the dose has been stabilized. Side effects should be evaluated as well as therapeutic effects on ADHD symptoms.

Nonstimulants Nonstimulants are considered a "second line" medication as a treatment for ADHD in children and adolescents. Atomoxetine is frequently combined with stimulants in young children. This approach is taken when stimulants are only partially effective. Having said that, this approach is controversial since other researchers have found no additional gain in effectiveness.

Other reasons to try nonstimulants are lack of tolerance of stimulants or other situations where they are contraindicated (Feldman et al., 2018). It is also noted that these nonstimulants are less likely to be abused since they do not result in a nonstimulant high, and it takes many hours or days before these medication results in the desired therapeutic effect.

Not surprisingly, the number and type of side effects from nonstimulant to stimulant drugs differ. With guanfacine XR sedation, somnolence and fatigue are frequently reported. Clonadine produces more side effects than guanfocine. Among the most commonly reported symptoms are sedation, dizziness, and hypertension. With these medications, the danger of abruptly stopping guanfocine or clonidine compared to stimulants must also be considered.

A number of other medications have been paired with stimulants which are typically considered a first-line medication for the treatment of ADHD. Among these are Atomoxetine, a selective noradrenalin reuptake inhibitor as well as tricyclic antidepressants and alpha-2-adrenergic agonists (Banaschewski et al., 2004).

The use of a second medication has to be parsed into two categories. Enhancing the effects of treating primary symptoms of ADHD is one purpose. Second, the American Academy of Pediatrics subcommittee on Attention-Deficit Hyperactive Disorder (2011) also stresses that comorbid disorders with ADHD should be evaluated as well. Among these concerns are anxiety disorders, conduct disorders, depression, language disorders, and oppositional defiant disorder. The target disorders/symptoms will dictate if a second medication is indicated and should dictate what medication and what dose are prescribed.

There are also some disturbing trends in concomitant drug use, especially with respect to psychotrophic medications. For example, despite the American Academy of Pediatrics recommendation against the use of off-label medications for ADHD, the off-label use of psychotropics is common (Cooper, Hickson, Fuchs, Arbogast & Ray, 2004). To compound the problem, atypical antipsychotics are most commonly used with ADHD relative to other diagnoses (Pathak, West, Martin, Helm & Henderson, 2010). For children, 1 in 5 are on psychotropic drugs, as a second medication for ADHD (Betts et al., 2014). This issue is a major challenge that needs to be addressed. However, given recent trends, improvement on this topic is unlikely.

26.6 Treatment Effectiveness

It is extremely important to establish medication effectiveness for ADHD. Also, clinicians should consider that the term effectiveness is not a monolith. Effectiveness can vary across core symptoms of ADHD. Other factors to consider are ancillary behaviors such as grades, conduct, or comorbid psychopathology. The rapid rise in medication use underscores this point. For example, the U.S. Drug Enforcement Agency (1999) has seen a 700% increase in the use of Methylphenidate from 1990 to 1997. Researchers have speculated that this marked increase continues as of this writing (Thorell & Dahlstrom, 2009). Other factors such as heavy promotion by drug companies may also be a factor.

One of the biggest problems in assessing drug effects for ADHD is the lack of uniformity in assessment methods (dependent variables). Standardized tests, self-report, parent report, and direct observation are among the methods used. So why are these variables important or why even bother about systematic assessment? After all, the majority of people who receive medications for ADHD are not evaluated for effectiveness beyond asking a parent and or teacher their impression of whether the child is doing better or not. For one, most professional organizations highly recommend systematic assessments. Thus, there is general consensus that this is important. Also, from a clinical perspective the more reliable, multimethod and specific the symptoms assessed the better the clinical decisions about medication will be.

Standardized Tests There are a substantial number of scales used in the evaluation of ADD in children. A brief overview is provided here. The reader is directed to Chapter 9, which has an excellent in-depth review of the topic. The advantage of these tests is that you have the same questions and/or tasks in the same order, and there are norms. As a result, the child you are evaluating can be compared to other children of their own age. Therefore, the magnitude and type of symptoms present at diagnosis and soon after medication is prescribed, can be used to assess effectiveness. Also, later assessments can be compared to earlier ones to determine if the medication is effective long term and if so to what degree. Among the many methods that are available, some of the most commonly used scales are the Conners Hyperactivity Scale (McGee, Clark, & Symons, 2000), the test of Variables of Attention, clinical interview based on the Diagnostic and Statistical Manual of the American Psychiatric Association and the WISC-III (Weschler Intelligence Scale for Children (Mayes et al., 2001), the Test of Variable of Attention version (TOVA), the Swanson, Nolan, and Pelhoi (SMAP) Questionnaire, and the Strength and Weakness of ADHD-Symptoms and the Normal Behavior Rating Scale (Swanson, Schuck, Porter, Carlson, Hartman… .Wigal, 2012). Many of these measures can be used for diagnosis and in addition they can be used to track the change in symptoms over time. Unfortunately, systematic tracking of treatment effectiveness appears to be a rarity.

26.7 Combined Treatments

Most guidelines for interventions for children and to a lesser degree with adults have common components. Psychological methods should be used first. When this approach is ineffective, then medications should be added. These methods continue to be recommended despite the fact that in practice medication only as an intervention for ADHD continues to be employed in most cases.

Many studies have been published reporting that using psychological interventions (typically using behavior therapy) plus medication is more effective than medication alone. For example, So et al. (2008) found that methylphenidate plus behavior therapy was more effective than methylphenidate alone in the treatment of ADHD symptoms of 90 children with a mean age of 8 years. These positive effects were noted at the end of 6 months of treatment and at a one-year follow-up.

Klein and Abikoff (1997) further underscore the value of using behavior therapy in conjunction with methylphenidate because even assuming that the medication is highly effective, it does not enhance prosocial behavior or academic achievement. Additionally, preexisting problems such as sleep problems and mood changes may preclude stimulants or limit dosages. They treated children from 6 to 12 years of age. Three groups were established: behavior therapy ($N = 28$), methylphenidate ($n = 29$), and behavior therapy plus methylphenidate ($n = 29$). Behavior therapy was provided at home and school. Basic operant methods such as reinforcement, time-out, loss of privileges, consequences, and rewards constituted behavior therapy. Reading assignments and discussions with therapists were used. When methylphenidate was prescribed, it was titrated to an optimal dose (best effects and fewest side effects) up to a maximum of 60 mg. daily. Behaviors assessed for effectiveness of interventions (dependent variables) included conduct disorders, inattention, anxiety, hyperactivity, and sociability. An overall severity index as measured on the Connor's Teacher Rating Scale was also used. A variety of items from the Hillside Behavior Scale were used as well. Topics involved gross motor activity, concentration, frustration tolerance, cooperation, attitude toward work, interest in tasks, attention seeking, behavior, impulse control, initiating aggressive behavior with peers, joining aggressive activities, and popularity. Ratings were made by teachers and mothers. The authors conclude that all three treatment groups achieved gains. Behavior therapy was least effective followed by methylphenidate. The combination of both treatments was the most effective. Combining behavior therapy with methylphenidate versus medication only has been observed in other studies (So et al., 2008). When discussing treatment effectiveness, they must be viewed in the short term but also in the long term. Such is the case since ADHD is seen as a chronic condition. Rajeh et al. (2017) conclude that stimulant medication was very effective during the period in which it was administered. On the other hand, behavior therapy was more effective than medication in enhancing executive function and organizational skills.

Another form of behavior other than personal or small group approaches involves classroom settings. Carlson et al. (1992) evaluated 24 boys with ADHD. Their intensive summer program employed a crossover design. Two classrooms were employed. Conditions involved B.I.D. meds, placebo and a classroom employing a program including a token economy, daily home report card, and time out. One classroom did not use these applied behavior analysis (ABA) methods. ABA only markedly improved ADHD symptoms. Medication was the only intervention that enhanced academic improvement. The combined treatment, as with many other studies reported the best improvements with the combined intervention.

Children and parents have been asked their opinion on medication effectiveness (Thorell & Dahlstrom, 2009). Seventy-nine children and one parent for each child were interviewed. Ninety-six percent of the children were taking methylphenidate while 4% were taking amphetamine for ADHD. Over 80% of the kids reported that their medication helped them concentrate more and over 70% said medication helped them to sit still and do their homework. About 60% noted improvement in social relationships. There were also reports of negative effects, but endorsements were lower. Loss of appetite was noted by 27% of respondents while 19% had difficulty falling asleep. When compared to parent responses, there was a great deal of agreement with parents being slightly more positive. However, 5% of children also indicated that they wanted to stop taking medication or sometimes wanted to stop.

Because of reluctance to take medication and complications associated with daily life (being disorganized, forgetting to take the medication, illness, and parents can't afford it) drug adherence can be an issue. Brinkman et al. (2018) noted that several factors impact long-term compliance. These authors noted seven variables. These were (1) parent perception of treatment effectiveness; (2) greater parent satisfaction with information about medication; (3) comfort with the treatment plan; (4) titrating medication to maximize benefits and minimize side effects; (5) parent comfort with the treatment; (6) timeliness of the titration; and (7) treatment effectiveness.

26.8 Final Remarks

Psychotropic medications and especially stimulants have been a stalwart in the treatment of ADHD for decades. A large number of studies have demonstrated efficacy. However, over time adherence as well as treatment effectiveness can wane. As a result, behavior therapy and applied behavior analysis have been added to the mix. These later methods are important for teaching adaptive skills which, of course, medications cannot do. Also, the educational approaches take longer to have an effect but result in better long-term effects. Thus, as of this writing, the combination of medication and behavior therapy and/or applied behavior analysis is the best option for the treatment of ADHD.

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